Department of Zoology,
University of Delhi, Delhi-110007

M.Sc. Zoology with Research
PGCF-Structure III
Semester-III

The Chairperson COC-PGCF
The Head
Department of Zoology
University of Delhi
Delhi-110007

Semester-Wise Details of M.Sc. Zoology with Research

Semester-III

Paper Codes: The first two letters (MS) in a paper code defines as M.Sc. course, the ZOOL defines as a course of Zoology and the last letter as C, E, GE and SBC defines as core, elective, general elective, skill based course, respectively. The first numeral defines the semester and the remaining two numerals defines stream and the paper number.

Semester III				
Core Course (Total No. 1)	Theory	Practical	Tutorial	Credits
MSZOOLC-R303 **Techniques in Zoology**	3	1	--	4
Total Credits in 1 Core Courses	**4**			
Discipline Specific Elective Course (DSE: Total No. 1)				
A student has to choose one DSE related to their Research from the following options:	Theory	Practical	Tutorial	Credits
MSZOOLE-307 Introduction to Genomics	3	--	1	4
MSZOOLE-308 Pregnancy Biology and Reproductive Technology	3	--	1	4
MSZOOLE-309 Insect Diversity, Society and Evolution	3	--	1	4
MSZOOLE-310 Fish Diversity, Taxonomy and Conservation	3	--	1	4
Total Credits from 1 Elective Courses	**4**			
	Theory	Practical	Tutorial	Credits
MS ZOOLRM-316: **Advanced Research Methodology**	1	--	1	2
MS ZOOLRT-317: **Research Tools**	0	2	--	2
MSZOOLD-318 **Dissertation (As per the guidelines of University of Delhi)**	**10**			
Total credits	**22**			

DISCIPLINE SPECIFIC CORE-7 (DSC-7)

MS ZOOLC-301: Techniques in Zoology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

SYLLABUS OF DSC-7

MS ZOOLC-301: Techniques in Zoology

Unit 1. Separation and analytical techniques 11 h

Principles of separation science: adsorption, partition, ion exchange and size exclusion; Chromatographic Methods: paper chromatography, thin layer chromatography (TLC), high-performance liquid chromatography (HPLC), gas chromatography (GC), affinity chromatography, ion exchange chromatography and size exclusion chromatography; Isolation and analysis of biomolecules: extraction and purification of DNA, RNA, proteins, carbohydrates and lipids; Basic principles of centrifugation; Introduction to mass spectrometry.

Unit 2. Spectroscopic and structural methods 10 h

Principles of spectroscopy: absorption, emission and scattering of light; wave and particle nature of light; interaction of electromagnetic radiation with biomolecules; Spectroscopic techniques: UV–Visible and fluorescence spectroscopy, fluorescence resonance energy transfer (FRET), fluorescence recovery after photobleaching (FRAP), infrared spectroscopy (FTIR) and circular dichroism; Structural determination methods: nuclear magnetic resonance (NMR), electron spin resonance (ESR), X-ray diffraction and cryo-electron microscopy.

Unit 3. Electrophoretic and immunological techniques 12 h

Principles of electrophoresis: migration of charged molecules in an electric field and factors affecting electrophoretic mobility; Electrophoretic Methods: agarose gel electrophoresis and polyacrylamide gel electrophoresis (PAGE); Advanced Electrophoretic Techniques: Native PAGE, SDS-PAGE, isoelectric focusing and two-dimensional gel electrophoresis; Immunological and molecular detection techniques: Antibody generation; ELISA, radioimmunoassay (RIA), western blotting, immunoprecipitation, flow cytometry and immunofluorescence microscopy; In situ hybridization methods: Fluorescence in situ hybridization (FISH) and genomic in situ hybridization (GISH).

Unit 4. Microscopy and electrophysiological methods **12 h**

Principles of microscopy: light, bright field, phase contrast, fluorescence and confocal microscopy; scanning and transmission electron microscopy; Sample preparation for microscopy: fixation, microtomy and staining methods; Electrophysiological methods: single neuron recording and patch clamp techniques.

Practicals **30 h**

1. Extraction and separation of lipids from egg yolk using Thin Layer Chromatography (TLC); calculation of Rf values
2. Isolation of genomic DNA from prokaryotic and eukaryotic cells and estimation of purity using UV spectrophotometer (A260/A280)
3. Agarose gel electrophoresis of DNA samples and analysis of band migration
4. Protein estimation using UV, Bradford or Lowry method and preparation of a standard curve
5. Differential centrifugation for separation of cellular components (using homogenized tissue suspension)
6. Extraction of proteins and lipids from tissues and analysis
7. Recording UV-Visible absorption spectra of biomolecules (DNA, protein) and application of Beer–Lambert law
8. SDS-PAGE of protein samples and molecular weight estimation by densitometry.
9. Indirect ELISA for detection of antigen or antibody
10. Microtomy and Light microscopy: preparation and staining of tissues and cells; analysis of images by Image J.

Essential/Recommended Readings

1. Wilson, Keith and Walker, John (Latest edition). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Cantor, Charles R. and Schimmel, Paul R. (Latest edition). Biophysical Chemistry: Parts I and II. W. H. Freeman and Company.
3. Sheehan, David (Latest edition). Physical Biochemistry: Principles and Applications. Wiley-Blackwell.

Suggested Readings

1. Alberts, Bruce et al. (Latest edition). Molecular Biology of the Cell. W. W. Norton and Company.
2. Branden, Carl-Ivar and Tooze, John (Latest edition). Introduction to Protein Structure. Garland Science.
3. Protein Data Bank (PDB) and NCBI Databases. (Latest editions). Online Bioinformatics Resources and Structural Databases.

DISCIPLINE SPECIFIC ELECTIVE-11A (DSE-11A)

MS ZOOLE-307: Introduction to Genomics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Integrate wet lab techniques and bioinformatics approaches in genome science.
- Understand sequencing technologies, genome editing tools and their applications.
- Develop critical thinking and research skills for academic, industrial, medical, and biotechnology careers.

Learning outcomes

By studying this course, students will be able to:

- Understand concepts and computational approaches to address complex biological questions in genomics research.
- Design and comprehend experimental strategies related to genomics using modern sequencing platforms.
- Develop basic understanding of bioinformatic tools and pipelines for genome assembly, annotation, variant calling, and data integration.

SYLLABUS OF DSE-11A

MS ZOOLE-307: Introduction to Genomics

Unit 1. Structural genomics 15 h

Organization, structure and complexity of genomes: genome architecture of viral, bacterial, mitochondrial and nuclear genome; Diversity of repeat elements: transposable elements, retrotransposons, SINE, LINE, Alu, pseudogenes, segmental duplications; Human genome project; Quality of genome-sequence data, base calling and sequence accuracy; Recognition of coding and non-coding regions and annotation of genes, three-dimensional chromatin structure, isochores, Topologically-associating domains (TADs); Structural variants (SVs): insertions, deletions, inversions, duplications, copy number variations (CNVs).

Unit 2. Sequencing platforms and advances in bioinformatics **15 h**

Comprehensive understanding of short read and long read sequencing platforms: Illumina, Oxford Nanopore Technologies (ONT); Sequencing strategies; Bioinformatics datasets; Demultiplexing; Sequence analysis based on alignment; *de novo* assembly and gene identification using *in silico* methods; Variant calling pipelines: SNP, CNV and indel detection, structural variant identification.

Unit 3. Phylogenomics and comparative genomics **8 h**

Introduction to phylogenomics: orthologs, paralogs, exon shuffling; Construction of phylogenetic trees from genome-scale data, gene/species tree reconciliation, synteny and collinearity analysis; Genome alignment strategies: Overall Genome Related Indices (OGRI); Bacterial comparative genomics: mobile genetic elements, horizontal gene transfer; Comparative genomics of organelles, and nuclear genome of eukaryotes; Pan-genome concepts: core and accessory genomes; Pan-genome analysis: core, accessory, and unique gene identification; Genome duplication events: whole-genome duplications, polyploidy; Comparative analysis of structural variations across populations; Genome India Project.

Unit 4. Advances in Genomic Research **7 h**

Single-cell genomics and transcriptomics (scRNA-seq); CRISPR-based functional genomics: gene knockout screens, CRISPRi, CRISPRa for functional annotation; Introduction to transcriptomics, epigenomics and genome-wide association studies (GWAS); Introduction to multi-omics research.

Tutorial **15 h**

Group discussions, presentations and assignments in contemporary Research topics

Essential/Recommended Readings

1. Watson, James D. et al. (Latest edition). Recombinant DNA: Genes and Genomics – A Short Course. W.H. Freeman and Company.
2. Primrose, Sandy B. and Twyman, Richard M. (Latest edition). Principles of Gene Manipulation and Genomics. Wiley-Blackwell.
3. Glick, Bernard R. et al. (Latest edition). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.

Suggestive Readings

1. Buffalo, Vince (Latest edition). Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools. O'Reilly Media.
2. Akalin, Altuna (Latest edition). Computational Genomics with R. Chapman and Hall/CRC.

DISCIPLINE SPECIFIC ELECTIVE-11B (DSE-11B)

MS ZOOLE-308: Pregnancy Biology and Reproductive Technology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Recognise the physiological changes in pregnancy and impact of life style and toxins.
- Understand gestational diabetes, pregnancy-induced hypertension in preeclampsia, and other disorders of pregnancy.

Learning outcomes

By studying this course, students will be able to:

- Integrate Basic science (endocrinology, immunology, physiology), Translational medicine (pregnancy disorders), Environmental health (chemical exposures) to public health relevance
- Understand that the obesity and exposure to pollution can affect fetal development and the outcome of the pregnancy.

SYLLABUS OF DSE-11B

MSZOOLE-308: Pregnancy Biology and Reproductive Technology

Unit 1. Foundations of pregnancy biology **10 h**

Implantation and uterine receptivity, Hormonal regulation of pregnancy: Corpus luteum, maintenance and luteal–placental shift, Decidualization and maternal immune tolerance, implantation window, and mechanism of implantation, Differentiation of cytotrophoblasts to syncytiotrophoblasts, Placental hormones: hCG, progesterone, estrogens, placental lactogen, Hypothalamic–pituitary–gonadal adaptations, Steroid hormone synthesis during pregnancy, Placenta formation and placental types (comparative mammals), Placental transport of nutrients and gases, Metabolic adaptations (insulin resistance, lipid metabolism), hormones and nutrition during pregnancy, Maternal nutrition and fetal programming

Unit 2. Immunity during pregnancy **7 h**

Placenta as Immune organ, Expression of HLA-G, Role of hormones in the regulation of the immune system during pregnancy; Theories and models of immune tolerance in the context of pregnancy; Autoimmune bases of infertility and pregnancy loss. Progesterone and immune tolerance, Maternal immune tolerance mechanisms, Role of uterine NK cells and cytokines, Neonatal Immunity: Breast milk is the first vaccine of life, Immunoglobulins in milk (IgA), Microbiome transfer from mother to infant, Bioactive factors in milk, Growth factors

Unit 3. Parturition, Lactation and Disorders of Pregnancy **15 h**

Uterine activation and myometrial contractility, Progesterone withdrawal hypothesis, Estrogen activation of myometrium, Oxytocin receptor expression, Role of prostaglandins, oxytocin and Inflammatory pathways initiating labour, Cervical ripening and fetal signaling, Neuroendocrine reflexes during labour, Molecular Mechanisms of Labour Onset; Pregnancy Disorders: Hormonal imbalance during pregnancy, Miscarriage, Preterm birth, Gestational diabetes, Preeclampsia, Placental insufficiency, Lactation failure, Mastitis, Hypogalactia, Choriocarcinoma, Placental insufficiency, Intrauterine growth restriction (IUGR), Environmental Perspectives: Endocrine disruptors affecting pregnancy, Microplastics and placental exposure to chemicals affecting pregnancy such as BPA, Phthalates, PVC, Organotins, Dioxins and Heavy metals

Unit 4. Emerging Research Frontiers and Methodologies in Pregnancy Biology **13 h**

Fetal programming and adult disease, Placental epigenetics, IVF, Maternal microbiome research, Hormone assays (ELISA, RIA), Fetal brain development, Placental histology, Immunohistochemistry, Ultrasound imaging, Single-cell RNA sequencing, Research Methods in Pregnancy Biology, Animal models of pregnancy, Model organisms such as Mouse, Sheep and Nonhuman primates, rodant models of PCOS, androgen exposure during pregnancy; Translational and Public Health Perspectives: Maternal health policies, Breastfeeding promotion programs, Environmental risks in pregnancy, Maternal–child health epidemiology, Exosomes and fetal signals, Placental aging and senescence

Tutorial **15 h**

Group discussions, presentations and assignments on translational topics: Developmental origins of adult disease (DOHaD hypothesis), Placental biomarkers in maternal blood, Artificial placenta technology, Organoid models of placenta, Case analysis of preeclampsia pathology, Nutritional analysis of human milk components, Histology of placenta, mammary gland and cancer, ELISA measurement of reproductive hormones, infant health, Transcriptomics of placenta.

Essential/Recommended Readings

1. Regulation of Implantation and Establishment of Pregnancy in Mammals, Editors: Rodney D Geisert, Fuller W. Bazer, ISBN 978-3-319-15856-3, Springer International Publishing, 2015.
2. Kovac CS and Kronenberg HM, Maternal-fetal interactions, pregnancy, puerperium and lactation. Endocrine Reviews.
3. Medical Biochemistry Human Metabolism in Health and Disease, Miriam D. Rosenthal Robert H. Glew, Wiley, A John Wiley & Sons, Inc. Publication

Suggestive Readings

1. Vertebrate Endocrinology, Fourth Edition, David O. Norris, Academic Press is an imprint of Elsevier.
2. Molecular Endocrinology, Third Edition, Franklyn F. Bolander, Academic Press, An Imprint of Elesvier.
3. Implantation and early development, Editors: Hilary Critchley, Ian Cameron and Stephan Smith, ISBN 9781107784680, Cambridge University press, 2014.
4. Implantation, Biological and Clinical Aspects, Editors: Michael G. Chapman, J. Gedis Grudzinskas, Tim Chard, ISBN 978-1-4471-3531-9, Springer-Verlag, 1988.

DISCIPLINE SPECIFIC ELECTIVE-11C (DSE-11C)

MSZOOLE-309: Insect Diversity, Society and Evolution

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To introduce students to the various orders and some of the most important families of insects so that they can distinguish between harmful and beneficial insects.
- To understand the unique morphological characters of the insects belonging to different orders, as well as their biology, natural history, and succinct features.
- To empower the students to appreciate the societal implications of insects.

Learning outcomes

By studying this course, students will be able to:

- Appreciate the value and importance of insects.
- Comprehend the basic biology and the significant identification characters of the insects.
- Learn the latest ideas of comparing these insects in an evolutionary perspective.
- Study insect societies and develop an ability to appreciate their implications on societal impacts.

SYLLABUS OF DSE-11C

MSZOOLE-309: Insect Diversity, Society and Evolution

Unit 1. Introduction to insects and their biology 8 h

Morphology: different sclerites and structures present in the head, thorax and abdomen.

Unit 2. Study of insect diversity 22 h

Comparative study of head-antennae, mouth parts, thorax-legs, wings, abdominal appendages and genitalia of the 29 orders including apterygote, exopterygote and endopterygote insects.

Unit 3. History and advances in the classification of insects **3 h**

Basis of insect classification; classification of insects up to suborders and up to super families in economically important groups; fossil history, origin and evolution of insects; use of molecular tools in taxonomy.

Unit 4. Insect societies and current research **12 h**

Groups of social insects and their life; Evolution of sociality: theories of social evolution; Levels of sociality; Social organisation and behaviour in honey bees, ants, termites, aphids and wasps; applications-role of social insects in agriculture and ecology; insects as bioindicators of climate change.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Imms, Augustus D. (Latest edition). A General Textbook of Entomology. Chapman and Hall.
2. Whitfield, James B. and Purcell, Alexander H. (Latest edition). Daly and Doyen's Introduction to Insect Biology and Diversity. Oxford University Press.

Suggestive Readings

1. Triplehorn, Charles A. and Johnson, Norman F. (Latest edition). Borror and DeLong's Introduction to the Study of Insects. Saunders College Publishing.
2. Snodgrass, Robert E. (Latest edition). Principles of Insect Morphology. Cornell University Press.
3. Wilson, Edward O. (Latest edition). The Insect Societies. Harvard University Press.

DISCIPLINE SPECIFIC ELECTIVE 11D (DSE-11D)

MS ZOOLE-310: Fish Diversity, Taxonomy and Conservation

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Practical	Tutorial			
4	3	0	1	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Understand the diversity and classification of fishes.
- Explore the evolutionary relationships among major fish groups.
- Learn the basic principles and modern methods used in fish taxonomy.
- Gain practical knowledge of morphological features, learn molecular tools used for fish identification and conservation.

Learning outcomes

By studying this course, students will be able to:

- Understand the diversity of fishes and evolutionary relationships using molecular tools.
- Explain key behavioural patterns observed in different fish species.
- Apply knowledge of fish biology to fisheries management practices.
- Use scientific understanding to support fish conservation strategies.
- Integrate fish biology concepts into aquaculture practices.

SYLLABUS OF DSE-11D

MS ZOOLE-310: Fish Diversity, Taxonomy and Conservation

Unit 1. Evolutionary diversity and fish biogeography 10 h

Origin and distribution of major groups of fishes; Evolutionary strategies across agnatha, chondrichthyes, actinopterygii and sarcopterygii; Global ichthyo-geographic regions and dispersal patterns, evolutionary drivers of fish diversity in riverine, lacustrine, deep-sea and coral reef systems.

Unit 2. Fish taxonomy, systematics and identification **10 h**

Taxonomic frameworks: historical and contemporary, phylogenetic systematics and cladistics, integrative taxonomy using morphology, meristic characteristics, challenges of cryptic species and phenotypic plasticity in freshwater and marine fishes.

Unit 3. Molecular methods in taxonomy **10 h**

Molecular systematics: genetic markers for species identification, mtDNA, nuclear genes, SNPs, microsatellites, DNA barcoding, e-metabarcoding and multi-locus sequence analysis (MLSA), next-generation sequencing (NGS), essential bioinformatics workflows for sequence processing, alignment, phylogenetic inference.

Unit 4. Current research in conservation and sustainable fisheries **15 h**

Status of global and Indian fish biodiversity: threatened and endemic species, major threats to fish diversity; Conservation: stock assessment, ecosystem-based fisheries management and conservation - river connectivity, environmental flows, and critical habitats, conservation genetics and molecular tools; Conservation governance: IUCN red list, Indian fisheries policies, protected aquatic areas, and community-based management, case studies in fish conservation.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Bone, Quentin and Moore, Richard (Latest edition). Biology of Fishes. Taylor and Francis (CRC Press).
2. Helfman, Gene S. et al. (Latest edition). The Diversity of Fishes. Wiley-Blackwell.
3. Helfman, Gene S. (Latest edition). Fish Conservation: A Guide to Understanding and Restoring Global Aquatic Biodiversity and Fishery Resources. Island Press.

Suggested Readings

1. Love, Milton S. and Cailliet, Gregor M. (Latest edition). Readings in Ichthyology. Prentice Hall.
2. Von der Emde, R. et al. (Latest edition). The Senses of Fish: Adaptations for the Reception of Natural Stimuli. Narosa Publishing House.
3. Tyus, Harold M. (Latest edition). Ecology and Conservation of Fishes. CRC Press.
4. Latest research articles.

ADVANCED RESEARCH METHODOLOGY-1 (ARM-1)

MS ZOOLRM-316: Advanced Research Methodology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
2	1	1	0	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Through rigorous hands-on training, students will gain proficiency in statistics and research methods in Zoology.

Learning outcomes

By studying this course, students will be able to:

- Design experiments and perform advanced statistics: two-way ANOVA, correlation, simple/multiple regression, PCA, clustering in R.

SYLLABUS OF ARM-1

MS ZOOLRM-319: Advanced Research Methodology

Unit 1. Advanced research methods in Zoology 7 h

Experimental model systems with respect to genetic variability, such as rodents, insect like drosophila, animal cell culture, transgenic mice, syngenic mice and in vitro cell-free systems; sample number calculation for human studies, functional genomics and RNAi tools, Concepts of experimental design in biological studies: randomization, replication and local control. Biostatistics concepts, Types of Data, Data management and computational tools.

Unit 2. Advanced biostatistics 8 h

Bivariate data and statistical relationships: Karl Pearson's correlation coefficient, properties and interpretation, and introduction to Spearman's rank correlation. Introduction to R and SPSS. Simple linear regression: fitting of regression line, regression coefficients, coefficient of determination and interpretation in biological terms; Introduction to multiple linear regression for modelling effect of more than one independent variable; Extension of analysis of variance: two-way ANOVA, post-hoc comparisons. Elementary concepts of multivariate analysis: need for

multivariate methods, simple idea of principal component analysis (PCA) and cluster analysis interpretation.

Tutorial **15 h**

Hands-on exercises and presentations
R Studio, Excel and GraphPad Prism software.

Essential/Recommended Readings

1. Introduction to Biostatistics and Research Methods, Fourth Edition, P. S. S. Sunder Rao, J. Richard, Prentice- Hall of India Private Limited.
2. Calculations for Molecular Biology and Biotechnology, A guide to Mathematics in the Laboratory, Frank H. Stephenson, Applied Biosystems, Academic Press, An Imprint of Elsevier.
3. Zar, Jerrold H. (Latest edition). Biostatistical Analysis. Pearson.

Suggested Readings

1. Computer Science and Data Analysis Series, Interactive Graphics for Data Analysis, Principles and Examples, Martin Theus Simon Urbanek, CRC Press Taylor & Francis Group, A & Hall Book.
2. Pagano, Marcello and Gauvreau, Kimberlee (Latest edition). Principles of Biostatistics. Chapman and Hall (CRC Press).
3. Latest software and articles available online.
4. Latest e-books and other textbooks.

RESEARCH TOOLS (RTW I)

MS ZOOLRTW-320: Research Tools

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
2	0	0	2	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Build foundational computational skills to efficiently manage, organize, and process large biological datasets (genomic, ecological, imaging).
- Enable students to use command-line tools and scripting for automation of repetitive research tasks such as sequence handling, data cleaning, and text processing.
- Prepare students to work with bioinformatics pipelines, high-throughput data, and research software commonly used in modern zoological and molecular biology studies.

Learning outcomes

By studying this course, students will be able to:

- Design computational strategies, critically evaluate scientific datasets, automate analyses, and apply reproducible, data-driven approaches to address complex biological research questions.
- Master Linux and python.
- Build automated, reproducible computational workflows for biological research and drug design.

SYLLABUS OFRTW I

MS ZOOLRTW- 320: Research Tools

Unit 1. Command-Line Computational Tools for Biological Data Analysis 18 h

Linux-Based Tools: Ubuntu overview - GUI vs CLI, filesystem hierarchy and permissions, apt package management; editors, advanced shell tools and scripting: file ops, text processing, stream editing, pattern scanning. Python Programming for Biological Data Analysis: Python setup and environments: system vs. Conda/Pyenv installs; virtual environments; Foundational Python: variables and data types; operators; user I/O, Data structures and modules: lists, tuples, sets, dicts; Comprehensions and lambda; Exception handling; Creating/importing modules and packages; pip installations; Jupyter notebooks and IDEs.

Unit 2. Image Analysis & Digital Zoology **12 h**

Image acquisition and analysis software, image processing for morphology and behaviour studies, Tools like ImageJ, Video tracking and behavioural analysis, scale bar insertion for microscopic slides, densitometry for SDS PAGE/western blot images, Editing of images for publications and scientific powerpoint presentation. Molecular docking: rigid, flexible, manual, protein-protein interaction, protein-ligand docking, docking-based screening, ligplot interaction, Introduction to MD simulation.

Essential/Recommended Readings

1. Pevsner, Jonathan (Latest edition). Bioinformatics and Functional Genomics. Wiley-Blackwell.
2. Mount, David W. (Latest edition). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
3. Computer Science and Data Analysis Series, Interactive Graphics for Data Analysis, Principles and Examples, Martin Theus Simon Urbanek, CRC Press Taylor & Francis Group, A & Hall Book.
4. Introduction to Biostatistics and Research Methods, Fourth Edition, P. S. S. Sunder Rao, J. Richard, Prentice-Hall of India Private Limited.

Suggested Readings

1. Claverie, Jean-Michel and Notredame, Cédric (Latest edition). Bioinformatics for Dummies. Wiley Publishing.
2. Latest software and articles available online.
3. Latest e-books and other textbooks.

Department of Zoology, University of Delhi, Delhi-110007

M.Sc. Zoology with Research

PGCF-Structure III

Semester IV

M.Sc. Zoology by Research-Semester-IV

Semester-Wise Details of M.Sc. Zoology Course- Semester-IV by Research (MSR)

Semester IV				
Choose one Research-specific Elective Course from the following	Credits in each elective course			
	Theory	Practical	Tutorial	Credits
Set I: Genomics Specialization				
MS ZOOLE-403 Transcriptomics, Proteomics and Metabolomics	3	1	--	4
MS ZOOLE-404 Microbiome and Metagenomics	3	1	--	4
MS ZOOLE-405 Translational Genomics, Epigenomics and Multi-omics	3	--	1	4
Set II: Molecular Endocrinology and Reproduction specialization				
MS ZOOLE-406 Environment, Epigenetics and Hormone Action	3	--	1	4
MS ZOOLE-407 Gametes and Reproductive Strategy	3	1	--	4
MS ZOOLE-408 Integrated Neuroendocrinology: Brain-Hormone interactions and health	3	1	--	4
Set III: Entomology specialization				
MS ZOOLE-409 Insect Physiology	3	1	--	4
MS ZOOLE-410 Insect Pests, Disease Vectors and Epidemiology	3	1	--	4
MS ZOOLE-411 Toxicology of Insecticides	3	--	1	4
Set IV: Fish Biology Specialization				
MS ZOOLE-412 Anatomy and Physiology of Fishes	3	1	--	4
MS ZOOLE-413 Aquatic Resource Dynamics, Biodiversity and Conservation	3	1	--	4
MS ZOOLE-414 Advances in Aquaculture	3	--	1	4
Total Credits from 1 Elective Course	**4**			
Research methods/Tools/Writing				
MSZOOLRW-420 **Research Writing**	1	0	1	2
Total Credits from Research methods/Tools/Writing	**2**			
MSZOOLD-421 **Dissertation (As per the guidelines of University of Delhi)**	16	0	--	16
Total Credits from Research	**22**			

Discipline Specific Elective-12A (DSE-12A)

MS ZOOLE-403: Transcriptomics, Proteomics and Metabolomics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	--	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To understand the fundamentals of transcriptomics, proteomics and metabolomics within the broader omics landscape and their integration into biological systems.
- Students will learn the principles, methodologies, and experimental workflows of transcriptomics, proteomics and metabolomics.
- Students will gain the skills for experimental design and data interpretation, and applications in biomedical, industrial, and environmental research.

Learning outcomes:

By studying this course, students will be able to:

- Design and execute transcriptomic, proteomic and metabolomic workflows.
- Analyze transcriptomic, proteomic and metabolomic datasets, and interpret results.

SYLLABUS OF DSE-12A

MS ZOOLE-403: Transcriptomics, Proteomics and Metabolomics

Unit 1. Foundations of RNA biology 10 h

Types of RNA and their genesis; RNA editing; Catalytic RNA molecules: mechanisms and secondary structures of ribozymes; Non-coding RNA in genome editing; RNA interference.

Unit 2. Principles and experimental approaches in transcriptomics 13 h

Introduction to transcriptomics; Methods for studying gene expression: Northern blot, RT-PCR, microarrays, functional annotation of genes; High-throughput gene expression and analysis: RNA sequencing (RNA-seq) technology and analysis workflow, RNA-Seq types: bulk, differential expression, small RNA, single-cell, spatial transcriptomics, library preparation and sequencing; 1859Data processing and quantification: quality control, read depth, alignment and

pseudoalignment; Differential expression and interpretation: statistical modeling, FDR correction; Data visualization; Functional and pathway analysis.

Unit 3. Principles and experimental approaches in proteomics 14 h

Origin and scope of proteomics; Strategies for protein separation: 2D gel electrophoresis, multidimensional liquid chromatography; Strategies for protein identification: sequencing by chemical degradation, mass spectrometry (basic instrumentation, Peptide mass fingerprinting, shotgun proteomics); Quantitative proteomics; Interaction proteomics; Protein modifications in proteomics; Applications of proteomics: clinical, industrial, and environmental applications.

Unit 4. Principles and experimental approaches in metabolomics 8 h

Definition and scope of metabolomics; Role in systems biology; Targeted vs untargeted metabolomics; Workflow of MS-based metabolomics: sample acquisition, extraction and separation, ionization, detection, data analysis and metabolite identification; Applications and case studies in clinical, pharmacological, nutritional, environmental, agricultural, and microbial metabolomics.

Practical 30 h

1. Extraction of total RNA.
2. RNA quality check and quantitation.
3. cDNA preparation and gene expression analysis.
4. qRT-PCR data analysis.
5. Analysis of 2D gel electrophoresis images using publicly available gel analysis software.
6. In silico analysis of peptide masses generated from tryptic digestion of proteins.
7. In silico prediction and functional interpretation of post-translational modifications
8. Access and analyse publicly available proteomics datasets.
9. Process and analyse metabolomics datasets using free web-based platform.
10. Demonstration of mass spectrometry and NMR.

Essential/Recommended Readings

1. Meister, Gunter (Latest edition). RNA Biology. Wiley-VCH.
2. Wilkins, Marc R. et al. (Latest edition). Proteome Research: Concepts, Technology and Application. Springer.
3. Twyman, Richard M. (Latest edition). Principles of Proteomics. Garland Science (Taylor and Francis).
4. Veenstra, Timothy D. and Yates, John R. (Latest edition). Proteomics for Biological Discovery. Wiley.

5. Nielsen, Jens and Jewett, Michael C. (Latest edition). Metabolomics: A Powerful Tool in Systems Biology. Springer.
6. Villas-Bôas, Silas G. et al. (Latest edition). Metabolome Analysis: An Introduction. Wiley-Blackwell.

Suggestive Readings

1. Liebler, Daniel C. (Latest edition). Introduction to Proteomics: Tools for the New Biology. Humana Press (Springer).
2. Westermeier, Reiner et al. (Latest edition). Proteomics in Practice: A Guide to Successful Experimental Design. Wiley-Blackwell.

Discipline Specific Elective-13A (DSE-13A)

MS ZOOLE-404: Microbiome and Metagenomics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Understand the structure, function, and dynamics of microbial communities in human and environmental systems.
- Learn the principles and applications of metagenomics.
- Develop skills to design, analyze, and critically evaluate microbiome studies in health and ecological contexts.

Learning outcomes

By studying this course, students will be able to:

- Apply marker gene analysis and diversity metrics to assess community structure.
- Apply metagenomics to address real-world questions in environmental and clinical settings.
- Critically evaluate scientific literature in microbiome and metagenomic research and discuss their applications in biotechnology, ecology, and human health.

SYLLABUS OF DSE-13A

MS ZOOLE-404: Microbiome and Metagenomics

Unit 1. Microbial biodiversity 9 h

Introduction to microbiome and resistome; Diversity: bacteria, viruses, fungi and protozoa; Diversity indices: alpha (richness, evenness indices), beta (community dissimilarity), gamma diversity (total diversity); Major microbiome projects: environmental DNA, biodiversity surveys, species detection and distribution.

Unit 2. Human microbiome in health and disease **13 h**

Maternal-fetal microbiome: impact of delivery mode (vaginal vs. Cesarean) on initial microbial seeding; Development of gut microbiota in infancy and its impact on health; Environment and lifestyle in development of microbiome; Human microbiome diversity: skin, oral, lung, gut and urogenital; Cross-talk between microbiome and metabolism; Microbiome dysbiosis in health and diseases.

Unit 3. Fundamentals of metagenomics **12 h**

Metagenomics: overview and applications; Key challenges: sampling bias, contamination, read depth variation; Culture-dependent and -independent techniques; Library preparation for metagenomic sample, marker gene analysis (16S rRNA, 18S rRNA, ITS); Assembly fundamentals: co-assembly strategies using MEGAHIT and metaSPAdes.

Unit 4. Metagenomics in practice **11 h**

Metagenome-assembled genomes (MAGs): recovery workflows, quality assessment (CheckM2, GTDB-Tk), binning approaches; Functional annotation of metagenomic data: functional gene classification, KEGG mapper for metabolic reconstruction; Whole-genome metagenome; Pan-genome analysis of MAGs to identify functional diversity and strain variation; Ethical, legal, and social implications (ELSI): privacy, informed consent, and responsible communication of microbiome research.

Practical **30 h**

1. Metagenomic DNA isolation.
2. Amplification of 18S rRNA gene from environmental samples.
3. Quality assessment, binning and assembly of MAGs.
4. Comparative genomics and core-pangenome analysis (multiple animal strains).
5. Analysis of real or simulated datasets, such as assembling a metagenome.
6. Functional profiling of microbial community in the metagenome of environmental samples.
7. Assessment of microbial community evenness and dominance using Simpson's and Shannon–Wiener diversity index.
8. Construction and interpretation of rarefaction curves.
9. Exploring therapeutic applications of Faecal Microbiota Transplantation through case studies

Essential/Recommended Readings

1. de Bruijn, Frans J. (Latest edition). Handbook of Molecular Microbial Ecology: Metagenomics and Complementary Approaches. Wiley-Blackwell.
2. Hozzein, Wael N. (Latest edition). Metagenomics: Basics, Methods and Applications. Springer.
3. Buffalo, Vince (Latest edition). Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools. O'Reilly Media.
4. Akalin, Altuna (Latest edition). Computational Genomics with R. Chapman and Hall/CRC.

Suggestive Readings

1. Galaxy Training Network. (Latest edition). Galaxy Training Materials. training.galaxyproject.org.
2. National Center for Biotechnology Information. (Latest edition). NCBI Education Resources.
3. Knight, Rob and Buhle, Brendan (2015). Follow Your Gut: How the Bacteria in Your Stomach Steer Your Health, Mood and More. Simon and Schuster (TED Books).
4. Bhadauria, Rekha et al. (Eds.) (Latest edition). Microbiome in Human Health and Disease. Springer Nature.
5. Haller, Dirk (Ed.) (Latest edition). The Gut Microbiome in Health and Disease. Springer Nature.
6. Primary research and review papers published in Nature, Science, Cell, Microbiome, and Gut.

Discipline Specific Elective-14A (DSE-14A)

MS ZOOLE-405: Translational Genomics, Epigenomics and Multi-omics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To expose the students to advanced genomics, epigenomics, and multi-omics.
- To understand the translational potential of omics research.
- Evaluate the role of epigenetics in gene regulation and disease.
- Integrate multi-omics data for personalized medicine.

Learning outcomes

After completing this course, students will be able to:

- Explain key concepts in translational genomics, epigenomics, and multi-omics integration.
- Students will interpret genomic variants, understand disease-associated epigenetic alterations, and analyse biological information across multiple-omics layers.

SYLLABUS OF DSE-14A

MS ZOOLE-405: Translational Genomics, Epigenomics and Multi-omics

Unit 1. Foundations of translational genomics 8 h

Principles and scope of translational genomics; Clinical impact of genetic variation: pathogenicity, penetrance, variable expressivity; Sequencing strategies: applications in resolving complex regions; Somatic vs germline variation; Polygenic risk scores; Genomic biomarkers in oncology; Pharmacogenomics and drug–gene interactions; Ethical, legal, and social considerations in genomic medicine.

Unit 2. Epigenomics in human health and disease 18 h

Overview of epigenetic regulation; Histone variants, histone modifications and chromatin writers/erasers/readers; DNA methylation in development, imprinting, ageing, and disease; Environmental epigenomics: nutrition, toxins, stress; Epigenetic dysregulation in cancer,

metabolic, immune, and neurodegenerative disorders; Epigenetic biomarkers; Epigenetic therapeutics (DNMT and HDAC inhibitors).

Unit 3. Principles of multi-omics integration **9 h**

Conceptual framework of multi-omics; Overview of omic layers; Study design for multi-omics; Approaches to data integration-horizontal, vertical, and diagonal; Dimensionality reduction and clustering; Network reconstruction. Single-cell multi-omics.

Unit 4. Clinical and translational applications **10 h**

Genetics of disease: monogenic disorders and polygenic risk, representative genome-wide association studies (GWAS); Diagnostic genomics and newborn screening, pharmacogenomics and personalized therapeutics; Pathogen genomics and outbreak surveillance, host-pathogen genomic interactions; Genomic data and multi-omics in metabolic diseases, developmental biology and ageing; Biotechnology and industrial applications of genomics; Major epigenomic atlases and recent trends in translational genomics.

Tutorial **15h**

Group discussions, presentations and assignments

Essential/Recommended Readings

1. Evans, James P. and Gelehrter, Thomas D. (Latest edition). Genomics and Personalized Medicine. Oxford University Press.
2. Allis, C. David et al. (Eds.) (Latest edition). Epigenetics (formerly Epigenomics: Methods and Protocols). Cold Spring Harbor Laboratory Press.
3. Aizat, Wan Mohd and Kamarudin, Siti Nur Hazirah Mohd (Eds.) (Latest edition). Multi-Omics Data Integration. Springer.
4. Sensen, Christoph W. and Innis, Michael A. (Eds.) (Latest edition). The Genomics Era: Genomics, Proteomics, and Bioinformatics. Wiley-Blackwell.

Suggestive Readings

1. Current literature and review papers published in Genome Biology, Nature Reviews Genetics, Nature Methods, Cell, Genome Research, and Epigenetics & Chromatin.
2. Cancer Genome Atlas Research Network (Latest edition). The Cancer Genome Atlas (Pan-Cancer Atlas). National Cancer Institute / NIH.
3. Genomics Education Programme (GEP). (Latest edition). Online Resources and Training for Genomics. NHS Health Education England.

4. Epigenomics Roadmap: A resource for epigenomics data and research (Online Resources)
5. Multi-Omics Data Integration (MODI): A resource for multi-omics data integration and analysis. (Online Resources)

DISCIPLINE SPECIFIC ELECTIVE-12B (DSE-12B)

MS ZOOLE-406: Environment, Epigenetics and Hormone Action

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To provide a comprehensive understanding of the responses to hormones and the mechanisms of signaling.
- To provide an overview of the relationship between normal reproductive health and the environment.
- To discuss the epigenetic changes due to the interaction of hormones and environment, along with their trans-generational effects on reproductive health in higher vertebrates.

Learning outcomes

After completing this course, students will be able to:

- Understand the importance of hormones in the maintenance of reproductive health in humans and animals.
- Undertake the therapeutic research jobs in various pharmaceutical companies as well as in hospitals, in addition to the IVF centers.

SYLLABUS OF DSE-12B

MSZOOLE-406: Environment, Epigenetics and Hormone Action

Unit 1. Modern concepts of hormones 12 h

Latest discoveries related to hormones as chemical signals for control and regulation of physiological processes; Major questions in the biology of hormones; Structure of peptide, protein and glycoprotein hormones; Biosynthesis of protein hormones; Storage and secretion of hormones, molecular mechanisms of regulation of biosynthesis and secretion; Inhibitors of hormone biosynthesis and their use; Purification and characterization of protein hormones; Structure-function relationships in different hormones and the latest technologies to study the hormone receptor binding and signal detection, like BRET/FRET; Techniques for quantitation of hormones. Design and development of hormonal assays.

Unit 2. Hormones, Receptors and mechanism of Action **13 h**

The mechanism of action of protein and steroid hormones; Signal discrimination, transduction and amplification in hormone-regulated physiological processes; Activation and inhibition of adenylate cyclase, control of gene transcription; Signal attenuation/desensitization; Mechanism of tyrosine kinase receptor action, Insulin, IGF and EGF receptor signaling; Structural domains, Tyrosine kinase receptor/Insulin receptor signaling, serine/threonine protein kinase cascades, Ras-activation of MAPK; Receptor dimerization; Genomic and non-genomic pathways in gene transcription activation by steroid receptors, Structural domains within steroid receptors, DNA binding properties of steroid receptors; Positive and negative regulation of gene expression by steroid receptor/transcription factor interactions, receptor/co-activator and receptor/co-repressor interactions.

Unit 3. Endocrine Hormones: modulators of metabolism, and immunity **10 h**

Gonadal and non-gonadal functions (Immunity and metabolism) of gonadotropin and steroid hormones such as estrogen and progesterone; Genetic, biochemical and molecular analysis of functional properties of receptors; Pharmacokinetics of hormones, Experimental approaches to examine hormone agonists/antagonists and medical uses. the concept of nanobodies as modulators of hormone action; Hormones as therapeutic agents.

Unit 4. Environmental epigenomics and hormonal regulation of Physiology **10 h**

Basic concepts of epigenetics, Environmental influences on epigenetic mechanisms, Epigenetic inheritance; Gene–Environment Interactions: hormone Action and Disease; transgenerational epigenetics; Role of endocrine disruptors in the causation of subfertility or infertility in transgenerational animal models or the human population; Unsolved problems in hormone biology.

Tutorial **15 h**

Group discussions, presentations and assignments

Essential/Recommended Readings

1. Endocrine and reproductive physiology, 4th edition, edited by Bruce A. White and Susan P. Porterfied, Paperback ISBN: 9780323087049 Elsevier Inc.
2. Molecular Biology of Steroid and Nuclear Hormone receptors, edited by Freedman L.P., ISBN978-1-4612-1764-0, Birkhauser, Boston, USA, 1998.
3. Essays in Biochemistry, the Nuclear Receptor Superfamily, I. J. McEwan, Portland Press
4. Receptor Signal Transduction Protocols, R. A. J. Challiss, University of Leicester, UK, Humana Press, Totowa, New Jersey.
5. Medical Biochemistry Human Metabolism in Health and Disease, Miriam D. Rosenthal Robert H. Glew, Wiley, A John Wiley & Sons, Inc. Publication

6. Basic Medical Endocrinology, Third Edition, H. Maurice Goodman, Department of Physiology, University of Massachusetts, Academic Press An imprint of Elsevier.

Suggestive Readings

1. Progress in Molecular Biology and translational science, Vol.143 gonadotropins from benchside to bedside, edited by T. Rajendra Kumar, 2016 ISBN: 978-0-12-801058-7, Elsevier Inc. 2018
2. Signal transduction 3rd edition, Author: Ijsbrand Kramer, ISBN: 9780123948038 Academic press, 2015.
3. Peer-reviewed journal articles, monographs and reviews as and when recommended.

DISCIPLINE SPECIFIC ELECTIVE-13B (DSE-13B)

MS ZOOLE-407: Gametes and Reproductive Strategy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Students understand why sperm and oocytes evolved to be structurally and functionally different.
- To understand hormonal regulation of gonadal functions, gametogenesis, and fertility.
- To develop a comprehensive understanding of the molecular mechanism behind sex determination and gametogenesis.
- To understand the behaviour of gametes in fertility and their response to contraceptives.

Learning outcomes

After completing this course, students will be able to:

- Understand the structure and function of gonads and gametes.
- Describe the factors affecting gametogenesis and gonadal functions.

SYLLABUS OF DSE-13B

MSZOOLE -407: Gametes and Reproductive Strategy

Unit 1. Gamete Biology **10 h**

Definition and significance of gametes, anisogamy (sperm vs egg differences), gamete diversity in vertebrates, evolution of gametes in vertebrates and invertebrates, reproductive strategies across species, sexual reproduction strategies in animals; Primordial Germ Cells (PGCs): Origin of germ cells during embryogenesis, migration of primordial germ cells to gonads, germ cell specification mechanisms; Molecular Regulators: BMP signaling, DAZL, VASA genes; Epigenetic reprogramming; Translational Link: Germ cell tumors, Developmental infertility.

Unit 2. Oogenesis and Oocyte Quality **12 h**

Oogonia proliferation, calcium oscillations, pronuclear formation, first mitotic division, primary oocyte formation, meiotic arrest, oocyte maturation and its regulation, follicular maturation, ovulation, hormonal Control (FSH, LH, Estrogen, Progesterone, activins, inhibin, AMH), zona pellucida, cortical granules, cytoplasmic maturation, primordial follicles, primary follicles, secondary follicles, graafian follicle; Cellular interactions: Oocyte-granulosa communication, Gap junction signaling; translational relevance: polycystic ovary syndrome (PCOS), premature ovarian failure, female subfertility and infertility.

Unit 3. Spermatogenesis and Sperm physiology **12 h**

Spermatogonial stem cells, spermiogenesis, hormonal regulation (FSH, LH, testosterone), supporting cells (sertoli cells, leydig cells), blood-testis barrier, testicular microenvironment, sperm structure and function structure, capacitation, hyperactivation, male infertility, sperm motility defects, oxidative stress in sperm, zona pellucida binding, sperm chemotaxis, acrosome reaction, membrane fusion and important molecules: IZUMO1, JUNO receptor, ZP proteins, male infertility: genetic basis for male infertility, male sterility**,** azoospermia**,** oligozoospermia, asthenozoospermia**,** varicocele, semen analysis.

Unit 4. Translational Gamete Biology **11h**

Genetic defects affecting gametes, research methods in gamete biology, hormone assays, fluorescence microscopy of gametes, assisted reproductive technologies (ART), important technologies: intracytoplasmic sperm injection, cryopreservation of gametes, in vitro fertilization assays; ART procedure: intracytoplasmic sperm injection; environmental and toxicological aspects: environmental toxins and fertility decline: lifestyle factors affecting sperm and oocyte quality, endocrine-disrupting chemicals affecting gametes (bisphenol A, Di(2-ethylhexyl) phthalate; Contraception: Natural method (Fertility awareness), Surgical, Physical/Barrier methods), Chemical methods, Immuno-contraception; Experimental Models: Mouse models, Zebrafish model, Human clinical samples.

Practicals **30 h**

1. Histology of testis and ovary of different age groups of rats to understand the sequence of events related to spermatogenesis and folliculogenesis and ageing effect.
2. Gonadectomy and sex steroids replacement therapy to see the effect on accessory sex organs of rats.
3. Isolation of testicular cells and ovarian follicular cells.
4. *In vitro* experiments with different testicular cells to provide the direct evidence related to humoral and cellular control of testicular functions.

5. Sperm count and motility: Role of epididymal proteins, mono- and divalent cations and pH in control of sperm motility.
6. Induction of superovulation and oocyte retrieval from oviduct of immature rat/mouse.
7. Surgical sterilization of male (vasectomy) and female rats (tubal ligation).

Essential/Recommended Readings

1. Oogenesis, Physiology of ovulation and Infertility in book entitled "Infertility from Basics to Advanced Reproductive Technology", Evangel publications (In association with FOGSI, India), ISBN: 9788197821660, 2025.
2. Yen & Jaffe's Reproductive Endocrinology-E-Book: Physiology, Pathophysiology, and Clinical Management. Elsevier Health Sciences, edited by Strauss, J. F., Barbieri, R. L., Dokras, A., Williams, C. J., & Williams, S. Z., 2023.
1. Knobil and Neill's Physiology of Reproduction, fourth edition, Vol 1 and 2, edited by Tony M. Plant and Anthony J. Zeleznik. Academic Press.
3. The ovary, edited by Peter C.K. Leung and Eli Y. Adashi, Elsevier (Academic Press), 2018
4. Endocrinology of the testis and male reproduction. Simoni, M., & Huhtaniemi, I. T Springer International Publishing), 2017

Suggested Readings:

1. Clinical Gynecologic Endocrinology and Infertility. Taylor, H. S., Pal, L., & Seli, E. Speroff's. Lippincott Williams & Wilkins, 2025
2. Male Reproductive Function, Christina Wang, Academic Publishers, 1999.
3. Cell and Molecular Biology of Testis, edited by Claude Desjardins and Larry L. Ewing. Oxford University Press US, 1993.
4. Recent review articles published in various journals: "Endocrine Reviews / Reproduction / Biology of Reproduction / General and Comparative Endocrinology/ Journal of Endocrinology.

DISCIPLINE SPECIFIC ELECTIVE-14B (DSE-14B)

MS ZOOLE-408: Integrated Neuroendocrinology: Brain-Hormone interactions and health

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Interpret how dysregulation of brain–hormone interactions contribute to disorders such as anxiety, depression, metabolic syndromes, and reproductive dysfunctions.

Learning outcomes

After completing this course, students will be able to:

- Comprehend the interaction of hypothalamus - pituitary axis, pineal gland with mental and reproductive health.
- Perform techniques applied to neuroendocrine research.
- Understand neuroendocrine regulation of metabolic diseases.

SYLLABUS OF DSE-14B

MSZOOLE-408: Integrated Neuroendocrinology: Brain-Hormone interactions and health

Unit 1. Milestones in Neuroendocrinology 13 h

Integration of central nervous system in mammals with endocrine system: Information flow in the brain: Neuromodulation vs Neurotransmission; Neuroendocrine neural circuits, Synaptic plasticity in hormonal control, Kisspeptin, Neurokinin B and RF amide-related peptide-3 signaling pathway in reproductive regulation, Leptin and Ghrelin signaling linking metabolism and reproduction, Principles and application of techniques used in neuroendocrinology: stereotaxis, immunohistochemistry, *in situ* hybridisation, neuroimaging; Chemogenetics (DREADDs), CRISPR gene editing in neuroendocrine circuits, advanced neuroimaging (fMRI, PET), mapping of hypothalamic circuits using optogenetics.

Unit 2. Hypothalamic-pituitary axis and physiology 12 h

Arcuate, Paraventricular Suprachiasmatic nuclei of the hypothalamus, Glial regulation of hormone secretion, Astrocyte–neuron communication, Neurovascular interfaces in the hypothalamus, Regulation of hypothalamic and pituitary hormone secretions; Impact of microenvironment on

neuroendocrine responses; Chemistry and physiology of releasing and release-inhibiting hormones (GnRH, GnIH, TRH, PRH, PIH, CRH, ACTH, NPY, Oxytocin, Vasopressin), modern models of pulsatile GnRH release and feedback mechanisms, Neuroendocrine Stress Axis, Synthesis and storage of oxytocin and vasopressin.

Unit 3. Pineal Gland and Circadian Biology 10 h

Role of pineal in circadian physiology, regulation of pineal secretion; Phylogeny and peculiarities of pinealocytes; Biosynthesis, regulation and functions of melatonin, melatonin rhythms - daily and seasonal effects, melatonin receptors; Molecular Circadian Clock: clock gene network including: CLOCK gene, BMAL1 gene and PER gene family, Light-mediated entrainment of circadian rhythms, Blue light effects on melatonin; Translational Chronobiology: Shift work disorders, Sleep disorders, Jet lag therapy; Chronopharmacology: abnormal Melatonin and Impact on reproductive physiology.

Unit 4. Neural Circuits, hormones and mental health 10 h

Neuroendocrinology of homeostasis: temperature regulation, hunger and satiety in mammals, stress response, immune function, and seasonal processes; Neuroendocrine changes during adolescence and puberty; POMC neurons, effects of stress, pharmacological drugs, smoking and alcohol on reproduction, Concept of neurosteroids: Neurosteroids and Brain Function, Effects on anxiety, cognition, and behaviour.

Practical 30 h

1. Preparation of brain for cryosection: Transcardial perfusion of rat and brain fixation.
2. Cresyl violet (CV) staining of rat brain to identify different brain nuclei.
3. Study of important brain areas and hypothalamic nuclei involved in neuroendocrine regulation.
4. Demonstration of the hypothalamic-hypophyseal portal system in rat brain.
5. Identification of different neuropeptides and areas of their localization in brain following immunohistochemical (IHC) methods.
6. Extraction of pituitary gland from rat/mice for histological studies.
7. Isolation of pituitary cells to study the effect of GnRH and its analogues in culture.

Essential/Recommended Readings

1. Handbook of Neuroendocrinology: George Fink, Donald W. Pfaff and Jon E. Levine(Eds.) 2012. Elsevier Inc.
2. An Introduction to Neuroendocrinology: Michael Wilkinson and Richard E Brown (2015), Cambridge University Press, UK.
3. Molecular Biology of Circadian Rhythms, Amita Sehgal Wiley- Liss, A John Wiley & Sons. Inc. Publication.

Suggestive Readings

1. Neuroscience: Exploring the Brain: 4th edition, Mark F. Bear, Barry W. Coonors and Michael A. Paradiso (2015). Wolters Kluwer.
2. Introduction to Behavioral Neuroendocrinology (5th edition), Randy J. Nelson and Lance J. Kriegsfeld (2016) Oxford University Press.

DISCIPLINE SPECIFIC ELECTIVE 12C (DSE-12C)

MS ZOOLE-409: Insect Physiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To understand various physiological systems in insects.
- To relate physiological mechanisms of organ systems to insect survival, adaptation, and ecological success.
- To integrate knowledge of insect physiology to interpret inter-organ cross-talk.

Learning outcomes

By studying this course, students will be able to:

- Comprehend various physiological systems in insects.
- Understand the neural or hormonal regulation within each system.
- Understand the relevance of insects as a eukaryotic model for translational research in higher vertebrates.

SYLLABUS OF DSE-12C

MSZOOLE-409: Insect Physiology

Unit 1. Endocrine and nervous system **12 h**

Insect hormones: key hormones involved in metamorphosis, reproduction, osmoregulation, metabolism and behaviour; Components and anatomy of nervous system; Sensing the environment: sensory receptors, receptor potential, vision and acoustics.

Unit 2. Digestive and excretory system **12 h**

Anatomy of alimentary tract: foregut, midgut, hindgut; Digestive physiology (enzyme secretion, absorption and symbiosis), nutritional requirements, role of fat bodies; Physiology of excretion, Malpighian tubules and osmoregulation, cryptonephridial system.

Unit 3. Circulatory and respiratory system **14 h**

Open circulatory system; dorsal vessel, accessory pulsatile organs; Role of hemolymph in immunity and thermoregulation; Tracheal system and physiology of gas exchange in terrestrial and aquatic insects.

Unit 4. Reproductive system **7 h**

Female and male reproductive systems, oogenesis, ovulation, spermatogenesis, transfer of sperm, fertilisation of the egg, embryogenesis, oviposition; Usual and unusual modes of reproduction.

Practical **30 h**

1. Comparative analysis of insect foregut, midgut and hidgut physiology.
2. Perform anatomical comparison between lepidopteran and dictyoptera digestive tract.
3. Quantify hemocytes in hemolymph obtained from infected insects to evaluate the immune response.
4. Effect of dietary treatment on insect gut, hemocyte profile, and excreta output.
5. Visualization of respiratory organs of different insects.
6. Visualization of male reproductive organs of different insects.
7. Visualization of female reproductive organs of different insects.

Essential/Recommended Readings

1. Wigglesworth, Vincent B. (Latest edition). The Principles of Insect Physiology. Chapman and Hall.
2. Chapman, R. F. et al. (Latest edition). The Insects: Structure and Function. Cambridge University Press.
3. Klowden, Marc J. (Latest edition). Physiological Systems in Insects. Academic Press (Elsevier).
4. Gullan, P. J. and Cranston, P. S. (Latest edition). The Insects: An Outline of Entomology. Wiley-Blackwell.
5. Nation, James L. (Latest edition). Insect Physiology and Biochemistry. CRC Press.

Suggestive Readings

1. Articles from Annual Review of Entomology and Current Opinion in Insect Science.

DISCIPLINE SPECIFIC ELECTIVE-13C (DSE-13C)

MS ZOOLE-410: Insect Pests, Disease Vectors and Epidemiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Familiarise students with major agricultural pests, their identification, seasonal history, damage, and core components of Integrated Pest Management (IPM).
- Develop a conceptual understanding of vector biology, pathogen transmission, and the medical importance of insect vectors.
- Introduce essential concepts of epidemiology, including disease transmission dynamics, measures of disease frequency and basic modelling tools.

Learning outcomes

By studying this course, students will be able to:

- Identify major insect pests and vectors, describe their biology, and explain factors contributing to pest or vector status.
- Diagnose pest damage and recommend appropriate IPM strategies based on ecological and biological information.
- Apply basic epidemiological tools to interpret disease data, calculate disease measures and understand transmission models (including R_o).

SYLLABUS OF DSE-12C

MSZOOLE-410: Insect Pests, Disease Vectors and Epidemiology

Unit 1. Insects as pests, their biology and control 16h

Agricultural pests: pest status and factors responsible for achieving the status of pest, economic injury level, economic threshold, action threshold, pest spectrum, pest complex, carrying capacity, secondary pest outbreak, pest surveillance and sampling; Locusts: Species, phases, phase transition, periodicity, migration, biology and control measures; Pests biology and control: identification, seasonal history, nature of damage and control measures of pests of cereals, pulse crops, cotton, vegetables, oil seeds, fruit crops, sugarcane and stored grains; Integrated Pest

Management (IPM): physical, cultural, chemical, biological control, genetic methods and biotechnological methods of pest control; Biorational methods: pheromones, JH mimics, MH agonists etc. in pest management.

Unit 2. Insect – host interactions **13h**

Insect-plant interactions: Role of allelochemicals, tritrophic interactions, host-plant selection; Plant resistance to insects: Types and mechanisms of resistance – antibiosis, antixenosis and tolerance factors; Insect-livestock interaction: host-seeking cues used by insects to locate livestock (olfactory, visual, thermal), livestock defensive responses, ecological and management factors influencing livestock–insect interactions; Insect-human interaction: Host-attraction mechanisms in medically and non-medically important insects (chemical, visual and thermal cues), host responses; Forensic entomology.

Unit 3. Medical entomology **8h**

Vector biology: evolution of disease vectors, modes of transmission of arthropod-borne communicable diseases, medical importance and management of the medically important insects (fleas, lice, bugs, mosquitoes and flies); Occurrence, causative agents, transmission and control of protozoan, bacterial, rickettsial and viral diseases by insects (fleas, lice, bugs, mosquitoes and flies).

Unit 4. Epidemiology **8h**

Foundations of epidemiology, disease transmission in vector-borne systems, measures of disease frequency, study designs in epidemiology of vector-borne diseases, compartment models and basic reproduction number (R_o), spatial, temporal and network epidemiology, epidemiology of insect-vectored plant, animal and human pathogens.

Practical **30h**

1. Identification of economically important insects and various stages of their life history.
2. Methods of rearing insects in the laboratory.
3. Identification of important insect pests of different crop plants and stored products.
4. Visits to agricultural fields and forests for on-spot study of pests and damage caused by them.
5. Study of life history stages of medically important arthropods, Diptera, Phthiraptera, Siphonoptera.
6. Identification and anatomical studies of major vector species of *Anopheles*, *Culex* and *Aedes*.
7. Life tables/population dynamics modelling.
8. Compartmental / dynamic-model simulation.

Essential/Recommended Readings

1. Schoonhoven, Louis M. et al. (Latest edition). Insect-Plant Biology. Oxford University Press.
2. Hill, Dennis S. (Latest edition). Agricultural Insect Pests of the Tropics and Their Control. Cambridge University Press.
3. Kettle, Douglas S. (Latest edition). Medical and Veterinary Entomology. CABI Publishing.
4. Service, Mike (Latest edition). Medical Entomology for Students. Cambridge University Press.
5. Bonita, Ruth et al. (Latest edition). Basic Epidemiology. World Health Organization.

Suggestive Readings

1. Jolivet, Pierre (Latest edition). Interrelationship Between Insects and Plants. CRC Press.
2. Pedigo, Larry P. and Rice, Marlin E. (Latest edition). Entomology and Pest Management. Prentice Hall.
3. Norris, Robert F. et al. (Latest edition). Concepts in Integrated Pest Management. Prentice Hall.
4. Mullen, Gary R. and Durden, Lance A. (Latest edition). Medical and Veterinary Entomology. Academic Press (Elsevier).
5. Lash, Timothy L. et al. (Latest edition). Modern Epidemiology. Wolters Kluwer.

DISCIPLINE SPECIFIC ELECTIVE-14C (DSE-14C)

MS ZOOLE-411: Toxicology of Insecticides

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To understand the evolution of insecticides.
- The course highlights various categories of insecticides and their mode of action.
- To understand the efficacy of chemicaland plant-based insecticides in the control of insect pests.

Learning Outcome

By studying this course, students will be able to:

- Describe various types of insecticides and their mode of action to control insects.
- Develop the concept of safer insecticides and management of insecticide exposure in humans.
- Gain comprehensive knowledge about the insecticide resistance and risk.

SYLLABUS OF DSE-14C

MSZOOLE - 411: Toxicology of Insecticides

Unit 1. Fundamentals of toxicology and classification of insecticides 7 h

Introduction to toxicology and insecticides: history, scope and definitions; Insecticide economics; Pesticide laws and regulations in India; Insecticide formulations: types, disposal, and application equipment.

Unit 2. Group characteristics of insecticides 13 h

Classification of insecticides: characteristics and function of organochlorines, organophosphorus, carbamates, pyrethroids, botanical insecticides, insect growth regulators, neonicotinoids, fumigants, inorganic insecticides, insect repellents, attractants and antifeedants, and other miscellaneous insecticide classes; The Insecticide Resistance Action Committee (IRAC) - based

pesticide classification; Concept of natural insecticides and organic farming; Uptake of insecticides.

Unit 3. Toxicokinetics, biotransformation and mode of action **15 h**

Evaluation of toxicity: dose-response relationship, LD_{50} and LC_{50}, probit analysis; Methods of testing: bioassay with insects, toxicology studies of insecticides on higher animals and estimation of teratogenicity, mutagenicity and carcinogenicity; Principles of pesticide metabolism: phase I and phase II metabolism, selective toxicity; Mode of action: nerve and muscle targets, growth and development targets, respiration targets, midgut targets, targeted protein suppressors and non-specific targets.

Unit 4. Insecticide resistance and contamination **10 h**

Insecticide resistance and management: mechanisms, cross-resistance, multiple resistance and pest resurgence; Modeling for predicting and managing resistance; Safer insecticides: next-generation molecules and their chemistry, nano-pesticides and advanced delivery systems; Non-target effects of insecticide application in the environment; Environmental contamination: type and severity of contamination, medical first aid, therapy and antidotes for insecticides; Ecological risk assessment, pollinator risk assessment, and good agricultural practices (GAP).

Tutorial **15 h**

Group discussions, presentations, and assignments

Essential/Recommended Readings

1. Whitford, Fred (Latest edition). The Complete Book of Pesticide Management. Wiley-Interscience.
2. Hodgson, Ernest and Kuhr, Ronald J. (Latest edition). Safer Insecticides: Development and Use. Marcel Dekker Inc.
3. Yu, Simon J. (Latest edition). The Toxicology and Biochemistry of Insecticides. CRC Press.

Suggestive Readings

1. Greim, Helmut and Snyder, Robert (Latest edition). Toxicology and Risk Assessment: A Comprehensive Introduction. John Wiley and Sons.
2. Matthews, Graham A. (Latest edition). Pesticide Application Methods. Wiley-Blackwell.
3. Richards, Isadora S. and Bourgeois, Marie (Latest edition). Principles and Practice of Toxicology in Public Health. Jones and Bartlett Learning.
4. Latest research papers published in Toxicological Sciences and Archives of Toxicology

DISCIPLINE SPECIFIC ELECTIVE-12D (DSE-12D)

MS ZOOLE-412: Anatomy and Physiology of Fishes

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To explain how different systems such as respiratory, circulatory, digestive, and nervous systems, function.
- To understand how organ system adaptation supports survival, growth, and performance in different aquatic environments.
- To develop a deeper appreciation of how fishes respond and adjust to environmental changes.

Learning outcomes

By studying this course, students will be able to:

- Understand how the major organ systems in fishes are designed to support specific functions.
- Explain how fish organ systems adapt to different aquatic environments and help in survival, growth and reproduction.
- Connect knowledge of organ systems with practical issues in fish health, aquaculture, environmental stress and conservation.

SYLLABUS OF DSE-12D

MSZOOLE-412: Anatomy and Physiology of Fishes

Unit 1. Comparative anatomy **12 h**

Comparative anatomy of skin, scales, and fins, digestive system, circulatory system, gill morphology, respiratory system and accessory respiratory organs, urinogenital system**.**

Unit 2. Swimming, buoyancy and physiological functions **13 h**

Swimming and buoyancy: swimming modes, strategies for buoyancy regulation, gas exchange, osmoregulation, acid-base balance**;** Physiology of feeding, digestive enzymes, digestion and

hormonal regulation; Cardiovascular physiology; Respiratory mechanisms and counter-current exchange.

Unit 3. Fish Immunity **10 h**

Basics of the fish immune system; Innate and adaptive immunity, types of antibody molecules and their function, role of antimicrobial peptides; Immunomodulation: role of environment and genetics.

Unit 4. Reproductive and sensory physiology **10 h**

Reproductive strategies, endocrine regulation through the hypothalamus-pituitary-gonadal axis, molecular mechanisms of oogenesis, spermatogenesis, fertilisation and development, environmental factors regulating reproductive cycle; Sensory receptors.

Practical **30 h**

1. Display of visceral organs of fishes of different feeding habits.
2. Demonstration of Weberian ossicles and internal ear.
3. Volumetric analysis of feeding habits, feeding intensity, and gastro-somatic index.
4. Comparative study of digestive enzymes of herbivore, carnivore, omnivore fishes.
5. Estimation of fecundity and gonado-somatic index of Indian major carp.
6. Study of accessory respiratory organs.
7. Collection of body fluids (blood, urine and gametes).
8. Determination of length-weight relationship and condition factor.
9. Study of various haematological parameters.
10. Isolation of phagocytes and estimation of phagocytosis.
11. Demonstration of antibody production and isolation in fish.
12. Demonstration of hypophysectomy on osmoregulatory parameters and gonadectomy on fish.

Essential/Recommended Readings

1. Farrell, Anthony P. et al. (Latest edition). Encyclopedia of Fish Physiology. Academic Press.
2. Hoar, William S. and Randall, David J. (Latest edition). Fish Physiology. Academic Press.
3. Evans, David H. and Claiborne, James D. (Latest edition). The Physiology of Fishes. CRC Press.

Suggested Readings

1. Currie, Suzanne and Evans, David H. (Latest edition). The Physiology of Fishes. CRC Press (Taylor and Francis).
2. Rankin, J. Cliff and Jensen, Frank B. (Latest edition). Fish Ecophysiology. Springer.
3. Eddy, F. Brian and Handy, Richard D. (Latest edition). Ecological and Environmental Physiology of Fishes. Oxford University Press.

DISCIPLINE SPECIFIC ELECTIVE-13D (DSE-13D)

MS ZOOLE-413: Aquatic Resource Dynamics, Biodiversity and Conservation

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To develop an understanding of the diversity of aquatic resources.
- To explain the structure and functioning of aquatic ecosystems and their ecological significance.
- To identify major threats to aquatic biodiversity.
- To understand key principles and strategies of aquatic conservation and restoration.
- To learn methods to assess ecosystem health using biological, chemical, and ecological indicators.

Learning outcomes

By studying this course, students will be able to:

- Assess the current status and distribution of aquatic resources at local, national, and global levels.
- Evaluate ecosystem health using biological and ecological indicators.
- Analyse the impacts of anthropogenic activities on aquatic biodiversity and ecosystem services.

SYLLABUS OF DSE-13D

MSZOOLE-413: Aquatic Resource Dynamics, Biodiversity and Conservation

Unit 1. Aquatic resources and biodiversity **10 h**

Inland fisheries: cold water, marine, estuaries, reservoirs, riverine, lacustrine; Impact of interlinking rivers on fisheries; Aquatic biodiversity: distribution of plankton, migration of zooplankton, benthos and bioindicators.

Unit 2. Conservation of aquatic resources **10 h**

Principles of aquatic ecosystem conservation, river conservation strategies, lake restoration approaches, Ramsar sites, wetland protection and management; Coastal and marine habitat

conservation (mangroves, coral reefs, seagrass beds);Habitat rehabilitation and community-based conservation.

Unit 3. Stock assessment and management **17 h**

Stock assessment: marking, tagging and population enumeration, length-weight relationship, age and growth; Fish stock decline: causes, impact of exotic and invasive species, illegal fishing practices and fishing gear management; Sustainable fishing technologies; Post-harvesting technology: methods of fish preservation, processing and marketing of fish products; Fishery governance, policies and legislation.

Unit 4. Aquatic pollution and monitoring tools **8 h**

Sources and types of water pollution: pesticides, heavy metals, microplastics and pharmaceutical pollutants, eutrophication; Biomonitoring: ecological indicators; GIS and remote sensing, sonar, in aquatic resource mapping.

Practical **30 h**

1. Fish faunal diversity survey from different aquatic resources.
2. Fish sampling using cast net/gill net, morphometric and meristic analysis.
3. Preparation of fish diversity checklist and IUCN status documentation.
4. Calculation of biodiversity indices: Shannon–Wiener Index, Simpson's index, species richness and evenness.
5. Qualitative and quantitative analysis of aquatic biodiversity in different water bodies: plankton, benthos and periphytic communities.
6. Wetland/river health assessment: Physico-chemical parameters (DO, BOD, pH, temperature, TDS, conductivity, nitrogen, phosphate).
7. Bioindicator assessment: Identification of pollution indicator organisms, biotic index calculation.
8. Estimation of heavy metals, microplastic isolation from water samples.
9. Estimation of primary productivity of aquatic resources.
10. Conservation of aquatic resources: mapping of Indian Ramsar site.
11. Fish stock assessment and population estimation.
12. GIS and Remote Sensing in aquatic resource mapping.

Essential/Recommended Readings

1. Jhingran, V. G. (Latest edition). Inland Fisheries of India. Oxford and IBH Publishing.
2. Wetzel, Robert G. (Latest edition). Limnology: Lake and River Ecosystems. Academic Press (Elsevier).
3. Dodds, Walter K. and Whiles, Matt R. (Latest edition). Freshwater Ecology: Concepts and Environmental Applications. Academic Press (Elsevier).
4. Hilborn, Ray and Walters, Carl J. (Latest edition). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall.

5. Gulland, John A. (Latest edition). Fish Stock Assessment: A Manual of Basic Methods. FAO (John Wiley and Sons).
6. Walker, Colin H. et al. (Latest edition). Principles of Ecotoxicology. CRC Press.

Suggested Readings

1. Ramsar Convention Secretariat. (Latest edition). The Ramsar Convention Manual: A Guide to the Convention on Wetlands. Ramsar.
2. Lillesand, Thomas M. et al. (Latest edition). Remote Sensing and Image Interpretation. Wiley.
3. Hall, George M. (Latest edition). Fish Processing: Sustainability and New Opportunities. Wiley-Blackwell.
4. Latest papers published in Environmental monitoring and assessment, Water researchand Science of the total environment.

DISCIPLINE SPECIFIC ELECTIVE-14D (DSE-14D)

MS ZOOLE-414: Advances in Aquaculture

CREDIT DISTRIBUTION, ELI GIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Knowledge of culture systems of freshwater, estuarine, and marine organisms.
- To identify the environmental and nutritional requirements of cultured species.
- To describe reproductive biology and seed production techniques.
- To decipher health, disease management and biosecurity.
- To understand molecular approaches in aquaculture.

Learning outcomes

By studying this course, students will be able to:

- Understand advanced techniques in aquaculture.
- Apply culture techniques for sustainable and efficient production of aquatic organisms.
- Integrate fundamentals of fish biology with aquaculture in research, fisheries management and entrepreneurship.

SYLLABUS OF DSE-14D

MSZOOLE-414: Advances in Aquaculture

Unit 1. Aquaculture status, systems and infrastructure **10 h**

Global status of fin and shellfish farming; Major constraints and opportunities in freshwater aquaculture; Aquaculture systems: extensive, semi-intensive and intensive systems, raceways, cages, flow-through systems, RAS, bio-floc and aquaponics; Carrying-capacity estimation, water quality standards and prospects for scaling freshwater aquaculture.

Unit 2. Fish seed technology and transport **10 h**

Natural seed collection, bundh breeding, induced breeding, cryopreservation of gametes; Feed types and feeding management; Routine sampling, growth monitoring and performance indices; Harvesting and grading.

Unit 3. Culture of major fish species and prawn farming **10 h**

Species selection and crop planning (IMC, catfish, tilapia, snakeheads, featherbacks, mahseer, trout); Prawn farming - seed quality assessment and stocking strategies, feeding and water quality management, common health issues, prevention and BMPs for prawn, harvesting, handling and economics of prawn farming including inland saline adaptations.

Unit 4. Integrated aquaculture, biosecurity and economics **15 h**

Integrated farming systems (fish + crops/livestock/vegetables/duck/poultry); Wastewater-fed aquaculture: treatment options, prebiotics, probiotics, synbiotics, NG probiotics; Major disease-causing pathogens - bacteria, virus, protozoans; Basic biosecurity, sanitary/quarantine considerations; Economics: waste-to-wealth approaches, value-addition and feasibility considerations.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Stickney, Robert R. (Latest edition). Aquaculture: An Introductory Text. CABI Publishing.
2. Costa-Pierce, Barry A. (Latest edition). Ecological Aquaculture: The Evolution of the Blue Revolution. Wiley-Blackwell.
3. Lekang, Odd-Ivar (Latest edition). Aquaculture Engineering. Wiley-Blackwell.
4. Zijpp, Akke J. van der et al. (Latest edition). Fishponds in Farming Systems. Wageningen Academic Publishers.
5. Pillay, T. V. R. and Kutty, M. N. (Latest edition). Aquaculture: Principles and Practices. Blackwell Publishing.
6. Dunham, Rex A. (Latest edition). Aquaculture and Fisheries Biotechnology: Genetic Approaches. CABI Publishing.
7. Zaccone, Giacomo et al. (Latest edition). Fish Defenses. Science Publishers.

Suggested Readings

1. Faudzi, Norfazreena Mohd et al. (Latest edition). Essentials of Aquaculture Practices. Springer Singapore.
2. Ahmed, Imtiaz and Ahmad, Ishtiyaq (Latest edition). Aquaculture: Enhancing Food Security and Nutrition. Springer Cham.
3. Latest review and research articles published in Aquaculture, Aquaculture research and Aquaculture International.

RESEARCH WRITING (RTW II)

MS ZOOLRTW-420: Techniques of Research Writing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
2	1	1	0	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To provide foundational skills in scientific writing and research documentation.
- To practice drafting key manuscript sections, review articles, using digital writing and plagiarism-detection tools, and understanding research integrity, authorship ethics, copyright issues, open-access policies, and predatory journals.
- To prepare proposals, concept notes, posters, presentations, and to communicate scientific ideas clearly to both expert and general audiences.

Learning outcomes

By studying this course, students will be able to:

- Differentiate between major research types and scientific document formats and apply appropriate structures in their own writing.
- Demonstrate responsible research practices by applying principles of research integrity, ethical authorship, plagiarism prevention, and correct identification of predatory journals.
- Communicate scientific information effectively, including designing figures, posters, presentations, and academic, technical writing.

SYLLABUS OF TRW

MS ZOOLTRW-420: Techniques of Research Writing

Unit 1. Foundations of scientific writing and research documentation 8 h

Different types of research, including experimental, observational, qualitative, and review-based studies; scientific documents such as research articles, review papers, systematic reviews, meta-analysis, short communications, case reports, technical reports, dissertations, and popular science writing for newspapers or blogs; Literature search using Boolean operators and MeSH terms, as well as proper referencing methods using APA, MLA, Vancouver, and Harvard styles; Reference

management tools like Zotero and Mendeley; Structured research manuscript writing - title, abstracts, keywords, results, tables, and figures, supplementary information; Journal selection – open access, subscription, journal policies.

Unit 2. Modern tools, research integrity, and scientific communication **7 h**

Research integrity concepts including plagiarism, data fabrication, authorship criteria under ICMJE, and identification of predatory journals using COPE guidelines; Digital writing tools; Plagiarism detection- Turnitin, iThenticate; Ethical use of AI platforms - Perplexity, SciSpace, and Elicit; Writing review of literature, position paper, preparing research proposals and concept notes, and designing scientific posters and oral presentations; communication of science to non-scientific audiences; Principles of data visualization, figure design using tools such as Canva and BioRender, and maintaining image integrity without manipulation.

Tutorial **15 h**

Hand-on projects, Assignments, and presentations

Essential/Recommended Readings

1. Gastel, Barbara and Day, Robert A. (Latest edition). How to Write and Publish a Scientific Paper. Bloomsbury Publishing.
2. Schimel, Joshua (Latest edition). Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded. Oxford University Press.
3. Hofmann, Angelika H. (Latest edition). Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford University Press.

Suggestive Readings

1. Committee on Publication Ethics. (Latest edition). COPE Core Practices and Guidelines. publicationethics.org.
2. World Association of Medical Editors (WAME). (Latest edition). Recommendations on Publication Ethics and Integrity. wame.org.
3. National Library of Medicine. (Latest edition). PubMed User Guide and MeSH Browser Tutorials. NIH.
4. National Library of Medicine. (Latest edition). Searching with MeSH: The NLM Online Training Series. NIH.