Department of Zoology,
University of Delhi, Delhi-110007

MSc. Zoology
PGCF-Structure I: Course work Based 2026
Semester III

From
The Chairperson PGCF-CoC
And The Head
Department of Zoology
University of Delhi
Delhi-110007

M.Sc. Zoology Courses
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 Courses (Total No. 2)	Theory	Practical	Tutorial	Credits
MSZOOLC-301 Computational Biology, Biostatistics and Bioinformatics	3	1	--	4
MSZOOLC-302 Principles of Ecology	3	1	--	4
Total Credits in 2 Core Courses	**8**			
Discipline Specific Elective Course (DSE: Total No. 3) A student has to choose three DSE or Two DSE (and one general elective) from the following options:				
Choose 2 DSE from the Following DSEs	Theory	Practical	Tutorial	Credits
MSZOOLE-303 Comparative Endocrine physiology of Vertebrates	3	1	--	4
MSZOOLE-304 Structure and Function of Gene	3	1	--	4
MSZOOLE-305 Advances in Immunology	3	--	1	4
MSZOOLE-306 Protein Structure, Function and Evolution	3	1	--	4
Select one DSE from the following DSEs				
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 3 Elective Courses	**12**			
Skill-Based Course:	Theory	Practical	Tutorial	Credits
Choose One SBC out of following Four SBCs				
MSZOOLS-311 Advanced Laboratory Courses in Genomics (Part- I)	0	2	--	2
MS ZOOLS-312 Advanced Laboratory Courses in Reproductive technology (Part I)	0	2	--	2
MS ZOOLS-313 Advanced Laboratory Courses in Entomology (Part I)	0	2	--	2
MS ZOOLS-314 Advanced Laboratory Courses in Fish Biology (Part I)	0	2	--	2
Total Credits from SBC	**2**			
General Elective (GE- 3) MSZOOLGE-315 **Behavior of Social Animals**	3	-	1	4

DISCIPLINE SPECIFIC CORE-7 (DSC-7)

MS ZOOLC-301: Computational Biology, Biostatistics and Bioinformatics

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:

- The course is designed so that the students are able to use computer programs for biologists to design the experiments, for data collection and analysis of results.
- The mandatory hands-on practical work in the Departmental computer lab will help students to maintain computers effectively for the large data analysis, presentation and innovation.

Learning outcomes

By studying this course, students will be able to:

- Manage computer systems, optimise Windows performance and learn ethical use of online information.
- Proficiently use MS Excel, Word, and PowerPoint for scientific data handling, analysis, visualization, and presentation. They will manage references and apply core biostatistics concepts for scientific dissertation.
- Retrieve biological data from large databases, and independently carry out biological data analysis and reporting.

SYLLABUS OF DSC-7

MS ZOOLC-301: Computational Biology, Biostatistics and Bioinformatics

Unit 1. Computational tools and software applications 10 h

Basic computer components for large data and Image analysis: Hardware (CPU, RAM, input/output/storage devices, network cards: IP address, proxy, VPN), system software (OS, kernel, BIOS), Windows file management (Defragmentation, Temporary file removal) and safe practices. Application software, introduction to MS Excel: use of worksheet to enter data, edit data, copy data, move data; Use of in-built statistical functions for computations of mean, S.D., S.E.M, correlation, regression coefficients, use of graphical tools such as bar diagrams, histograms, scatter plots and line graphs; Macros for presenting zoological data; Presentation of data; Introduction to MS Word: typing, editing, formatting, table insertion, figure captions, drawing simple flowcharts and shapes; Introduction to PowerPoint: slide designing, themes, insertion of images/charts from Excel, animations, image and data handling; Introduction to

research, scientific writing, ethical practices and reference management through Paperpile/Mendeley/Zotero /EndNote, importing references from PubMed/Google Scholar, PDF organisation, external addons, integration in word, reference formats in APA/Vancouver styles; Computer viruses and worms; Bioinformatics vs Computational biology; Introduction to artificial intelligence (AI) tools: AI models and ethics in data and image management, Plagiarism.

Unit 2. Biostatistics **16 h**

Types of variables, primary and secondary data in biological research, screening and representation of data, frequency distribution and tabulation; Measures of central tendency: mean, median, mode, quartiles and percentiles; Measures of dispersion: range, variance, standard deviation and coefficient of variation; Understanding of biological samples such as collected from cell culture, animal models, human population and self-reported datasets; Introduction to probability and random variables, basic probability rules, and common probability distributions - binomial, Bernoulli, Poisson and normal; Fundamentals of statistical inference: concept of sample size, sampling error, null and alternative hypotheses, level of significance, type I and type II errors and p-value; Introduction to parametric tests and non-parametric tests: one-sample data analysis, paired and unpaired data analysis, calculation of percentage, ratios and fold change, one-way ANOVA for comparison of more than two means, Chi-square test for association, Mann–Whitney U test, Kruskal–Wallis test.

Unit 3. Basic bioinformatics-databases, sequence analysis and tools **11 h**

Databases: nucleic acid sequence databases: GenBank, UCSC, Ensembl, EMBL, DDBJ; protein sequence databases: Swiss-Prot, PDB; Sequence similarity searching: BLAST, PSI-BLAST (steps involved in use and interpretation of results), HMMER; BLAST vs FASTA; File formats: FASTA, GCG, ClustalW; Databank search: data mining, data management and interpretation; Sequence alignment – Local/Global alignment, Multiple sequence alignment of genes, primer designing for gene amplification and cloning; Advanced Phylogeny: Bayesian inference.

Unit 4. Structural bioinformatics and protein analysis **8 h**

Proteins: secondary structure and folding; Discovery studio for protein visualisation, Protein secondary structure prediction tools: Chou-Fasman, GOR, Jpred; Structural modeling: structure prediction in 1D space, scoring function; Building models: homology modeling, fold recognition, Ab initio methods, modeling side chains. Molecular modelling, identification and characterization of proteins by mass fingerprint and MS/MS data analysis. Protein modelling and protein structure analysis.

Practical **30 h**

1. Introduction to computer systems: system management, graphics cards, temporary folders, proxy settings.
2. Use of scientific search engines: PubMed, Scopus, Entrez, Science Direct for literature search and reference management.
3. Introduction to Microsoft Excel: data entry, cleaning, organization, and basic operations.
4. Learning biostatistics in Excel: calculation of mean, median, and mode.
5. Statistical analysis in Excel using Analysis ToolPak: T-test and ANOVA**.**
6. Sequence retrieval from major biological databases and file formats.
7. Accessing and analysing genetic and disease information using OMIM.
8. Primer designing for gene amplification and cloning applications.
9. Web-based tools for sequence search and homology screening (BLAST).
10. Protein - protein interaction analysis using STRING and CORUM.
11. Bayesian phylogenetic analysis using BEAST2**.**

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. 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.
3. Pevsner, J. (Latest edition). Bioinformatics and Functional Genomics. Wiley-Blackwell, Inc. New-Jersey, US.
4. Mount, D. W. (Latest edition). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, New York, USA.
5. Zar, J.H. (Latest edition). Biostatistical Analysis. Pearson College Div. USA.

Suggestive Readings

1. Pagano M., Gauvreau, K. (Latest edition). Principles of Biostatistics. Chapman and Hall, USA.
2. Claverie J. M., Notredame C. (Latest edition). Bioinformatics for Dummies. Wiley Publishing, Inc., New York, US.
3. Latest software and articles available online.
4. Latest e-books and the textbooks available online.

DISCIPLINE SPECIFIC CORE-8 (DSC-8)

MS ZOOLC-302: Principles of Ecology

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:

- Learning the fundamental concepts of ecology, including natural selection, population growth and regulation, species interactions, community organisation, and ecosystem functioning.
- Know the effects of climate change, habitat alteration, and anthropogenic disturbances on biodiversity and ecosystem functioning.
- Develop the ability to apply ecological knowledge to real-world challenges in conservation, sustainability, and environmental management.

Learning outcomes

By studying this course, students will be able to:

- Critically examine core ecological principles governing population dynamics, species interactions, community organisation, and ecosystem processes.
- Apply quantitative and analytical tools to evaluate ecological data and test ecological hypotheses.
- Integrate ecological theory with practical approaches in conservation biology, environmental management, and sustainability planning.

SYLLABUS OF DSC-8

MS ZOOLC-302: Principles of Ecology

Unit 1. Evolutionary ecology and species interactions 10 h

Ecology's evolutionary backdrop: ecology of speciation, effects of climatic change on the evolution and distribution of species, effects of continental drift on the ecology of evolution, and life-history patterns; Species interactions: population dynamics, predation and community structure, ecological effects of interspecific competition; Ecological modelling.

Unit 2. Biogeochemical cycles and biodiversity **15 h**

Global biogeochemical cycles: exchanges among the atmosphere, ocean and land; Ecological biogeography: influence of greenhouse gases on earth's energy balance and climate, fate of CO_2 emission, uptake by oceans, effect of climate change on human health; Degradation in urban and industrial landscapes, maintenance and restoration of ecosystem; Threats to biodiversity: effects of invasive species on native species, habitat conservation, reintroduction and reestablishment of threatened species and environmental ethics in conservation.

Unit 3. Environmental toxicology **12 h**

Scope and principles of environmental toxicology; Major classes of contaminants, chemicals of emerging concern in surface and wastewater, Persistent Bioaccumulative Toxic (PBT) substances and Persistent, Mobile, Toxic (PMT) compounds/ Persistent and Mobile Organic Compounds (PMOC); Biodegradability, toxicity, and risks of pollutants, their consequences on biosphere; Toxicokinetics and toxicodynamics; Uptake, biotransformation, detoxification, elimination and accumulation of toxicants; Factors influencing bioaccumulation from food and trophic transfer; Bioindicators and biomarkers of environmental health; Decontamination technologies of soil and water.

Unit 4. Bioremediation **8 h**

Principles of biodegradation and bioremediation: microbial remediation, phytoremediation, rhizoremediation, bio-stimulation, bioaugmentation; *In situ* and *ex situ* bioremediation technologies: bio-piles, land farming, bioreactors, bio-slurries, constructed wetlands, reactive barriers; Genetic and enzymatic basis of biodegradation, engineered microbes and plants, microbial consortia and biofilms.

Practical **30 h**

1. To analyse physico-chemical properties of river, pond and lake water in Delhi region.
2. To assess density, frequency and abundance of plants/animals in a community using quadrat methods and analyse basic diversity indices.
3. To evaluate the role of arthropods and soil micro/macrofauna in decomposition using exclusion/meshsize experiments and laboratory sorting/identification.
4. To study ecosystem succession by comparing species composition and soil properties across different seral stages of a habitat.
5. To identify aquatic organisms belonging to different trophic levels and construct corresponding food chains and food webs.
6. To conduct an acute toxicity bioassay of chemicals and determine their LC_{50}/ EC_{50}.
7. To study principles of GIS, GPS and remote sensing technology through hands-on introduction to coordinate acquisition and map handling.
8. To calculate simple landscape metrics for habitat quality and connectivity (patch size, edge length, fragmentation indices) from classified maps.

Essential/Recommended Readings

1. Odum, Eugene P. (Latest edition). Fundamentals of Ecology. Cengage Learning.
2. Smith, Thomas M. and Smith, Robert L. (Latest edition). Elements of Ecology. Pearson Education.
3. Bowman, William D. et al. (Latest edition). Ecology. Oxford University Press.
4. Begon, Michael et al. (Latest edition). Ecology: From Individuals to Ecosystems. Wiley-Blackwell.
5. Townsend, Colin R. et al. (Latest edition). Essentials of Ecology. Wiley-Blackwell.

Suggested Readings

1. May, Robert M. and McLean, Angela R. (Latest edition). Theoretical Ecology: Principles and Applications. Oxford University Press.
2. Sinclair, Anthony R.E. et al. (Latest edition). Wildlife Ecology, Conservation, and Management. Wiley-Blackwell.
3. Latest research papers: Journal of Hazardous Materials, Pollution Research, Environmental Pollution

DISCIPLINE SPECIFIC ELECTIVE-9A (DSE-9A)

MSZOOLE-303: Comparative Endocrine Physiology of Vertebrates

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:

- To develop an understanding of the evolution of the endocrine system and hormones.
- To understand the role of various hormones in different vertebrate classes.
- To understand the role of hormones in regulation of various physiological functions.

Learning outcomes

By studying this course, students will be able to:

- Provide an insight into the evolution of hormones and the endocrine system.
- Understand variation in the physiological functions of hormones across vertebrates.

SYLLABUS OF DSE-9A

MSZOOLE-303: Comparative Endocrine Physiology of Vertebrates

Unit 1. Concept of comparative endocrine physiology of pituitary gland 12 h

A brief history of hormones and endocrinology, Introduction to the endocrine system and classes of hormones; Evolution of pituitary gland, physiological actions of pituitary hormones-adenohypophysial hormones: somatotropin and prolactin; Glycoprotein hormones (FSH, LH, and TSH), Pro-opiomelanocortin; Neurohypophysial hormones: Oxytocin and vasopressin; Urophysis (fishes): Urotensin.

Unit 2. Evolution of adrenal gland 11 h

Comparative account of the adrenal gland; Synthesis of corticosteroid, structural diversity and roles of glucocorticoids among vertebrates; Evolution of renin-angiotensin system, hormonal control of water and electrolyte balance; Catecholamine biosynthesis, its storage and release mechanism, importance of adrenocortical and adrenomedullary interaction, physiological actions of adrenal medullary hormones.

Unit 3. Evolutionary endocrinology of Thyroid **11h**

Thyroid hormone synthesis and its regulation; Paradigms of thyroid hormone action in poikilotherms and homeotherms; A comparative account of parathyroid gland and ultimobranchial body/C cells; Synthesis of parathyroid hormone, calcitonin and vitamin D3; Benthic organisms and source of vitamin D; Hormonal regulation of calcium and phosphate homeostasis.

Unit 4. Gastrointestinal tract and hormonal regulation of feeding behaviour **11 h**

Hormones of the gastrointestinal tract across vertebrates: their structure and function, including acid release, maintenance of pH of GI tract, gall bladder contraction/relaxation, pancreatic enzyme secretion and GI tract motility; Evolution of pancreas, pancreatic hormones and glucose homeostasis, Diabetes type II, hormonal control of feeding behaviour: central and peripheral regulation of food intake in vertebrates.

Practical **30 h**

1. Pituitary cytology: a comparative study following histology, histochemistry and immunocytochemistry.
2. Role of glucocorticoid in carbohydrate, lipid and protein metabolism following adrenalectomy and glucocorticoid replacement therapy in rats.
3. Role of thyroid hormone in oxygen consumption and reproduction in rat/wall lizard following thyroidectomy and thyroid hormone replacement therapy.
4. Steroid and thyroid hormone assay by ELISA.
5. Calcium estimation following fluorometry in PTH/Calcitriol-treated rats.
6. Effect of orexigenic and anorexigenic hormones on feeding behaviour of rats.
7. Induction of vitellogenesis in a seasonally breeding non-mammalian vertebrate.

Essential/Recommended Readings

1. Norris, David O. and Carr, James A. (Latest edition). Vertebrate Endocrinology. Elsevier Academic Press.
2. DeGroot, Leslie J. et al. (Latest edition). Endocrinology. Elsevier Health Sciences.

Suggested Readings

1. American Physiological Society. (Latest edition). Handbook of Physiology, Section 7: The Endocrine System. Oxford University Press.
2. Bentley, P. J. (Latest edition). Comparative Vertebrate Endocrinology. Cambridge University Press.
3. Review articles published in various journals: Endocrine Reviews/General and Comparative Endocrinology/Journal of Endocrinology/ International Review of Cytology/Molecular and cellular endocrinology/The journal of Clinical Endocrinology and Metabolism/Indian Journal Endocrinology and Metabolism.

DISCIPLINE SPECIFIC ELECTIVE-9B (DSE-9B)

MSZOOLE-304: Structure and Function of Genes

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:

- To understand the structural organization and physicochemical properties of nucleic acids and chromatin in relation to their biological functions.
- Illustrate post-transcriptional processing and regulatory roles of RNA molecules.

Learning outcomes

By studying this course, students will be able to:

- Analyse relationships between nucleic acid structure, chromatin organization, and genetic function using molecular and biochemical principles.
- Evaluate how post-transcriptional modifications and RNA processing contribute to gene regulation and proteome diversity.
- Integrate molecular events from genome organization to translation to predict outcomes of genetic variation or regulatory changes in cells.

Syllabus of DSE-9B

MSZOOLE-304: Structure and Function of Genes

Unit 1. The genetic material: structural perspective 11 h

Structure of nucleic acids - folding motifs, conformation flexibilities, super-coiling of DNA; Packaging of DNA in the nucleus - structure of chromatin, chromatin territories; Structure and function relationships in the genetic material; Energetics of nucleic acid polymerization; Accuracy during flow of genetic information.

Unit 2. Flow of genetic information 15 h

Comparison of prokaryotic and eukaryotic DNA replication: types of DNA polymerases, initiation, termination and proof-reading; Errors and damage in DNA; Mechanisms of DNA repair; Genome instability; Homologous and site-specific recombination: models and mechanisms in prokaryotes and eukaryotes; Basic transcriptional machinery in prokaryotes and eukaryotes: types of RNA polymerases and promoters, initiation, elongation and termination;

Transcriptional control: positive and negative regulation, regulatory sequences, activators and repressors, regulation of transcription-factor activity.

Unit 3. Post-transcriptional processing and regulation **12 h**

Processing of the 5' and 3' ends of eukaryotic pre-mRNA; Types of introns and their splicing, evolution of introns; Catalytic RNA; Alternative splicing and proteome diversity; Regulation of alternative splicing; Processing of rRNA and tRNA precursors; Micro RNA and other noncoding RNAs; RNA transport across nuclear envelope: structure of the nuclear membrane and the nuclear pore complexes, processes of nuclear import, export and their regulation.

Unit 4. Fate and functions of RNA **7 h**

Stability of RNA; Degradation of RNA; Translational machinery and its control: tRNAs and their modifications, amino-acyl tRNA synthetases, accuracy during aminoacylation of tRNA; Translation in prokaryotes and eukaryotes: initiation, regulation, elongation and its control, termination.

Practical **30 h**

1. Growth curve for bacteria: Plotting semi log graph of growth curves and its analysis using data provided.
2. Familiarization with sterile-handling techniques to culture bacteria.
3. Study of growth of *E. coli* in Lysogeny broth batch culture and determination of generation time and log-phase from the growth curves.
4. Study of growth of *E. coli* in M9 minimal medium batch culture for determination of log-phase for metabolic experiments.
5. Induction of lac operon in *E. coli* with lactose.
6. Catabolite repression of lac operon and role of cAMP.
7. Isolation of genomic DNA from mouse/rat liver or cell line.
8. Measurement of absorption spectrum of DNA, RNA, and nucleotides.
9. Construction of DNA double helix model.
10. qRT-PCR data analysis.

Essential/recommended Readings

1. Watson, James D. et al. (Latest edition). Molecular Biology of the Gene. Pearson (Affiliated East-West Press).
2. Krebs, Jocelyn E. et al. (Latest edition). Lewin's Genes XII. Jones and Bartlett Learning.
3. Lodish, Harvey et al. (Latest edition). Molecular Cell Biology. W.H. Freeman and Company (Macmillan Learning).

Suggestive Readings

1. Alberts, Bruce et al. (Latest edition). Molecular Biology of the Cell. W.W. Norton and Company.
2. Kirkwood, Thomas B.L. et al. (Latest edition). Accuracy in Molecular Processes: Its Control and Relevance to Living Systems. Chapman and Hall (Springer).

DISCIPLINE SPECIFIC ELECTIVE-10A (DSE-10A)

MSZOOLE-305: Advances in Immunology

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:

- Students will be introduced to the advanced concepts of immunology, facilitating a smooth transition into the more complex aspects of the subject.
- This paper is designed to allow the students to understand translational aspects of immunology.

Learning outcomes

At the end of the course, the students should be able to:

- Understand the nuances and mechanisms of innate and adaptive immunity.
- Understand how the host and pathogens interact and underlying mechanisms of immune evasion that pathogens employ to cause infections.
- Apply recent immunological techniques for research and patient welfare.

SYLLABUS OF DSE-10A

MS ZOOLE-305: Advances in Immunology

Unit 1. Molecular basis of innate sensing 8 h

Function, regulation and therapeutic potential of PRRs (TLR, NLR, CLR, RLR); Role of mitochondria and ER in anti-microbial immunity; Pathogen-induced cell death and autophagy; Innate control of adaptive immunity; Epigenetic control of innate immune dynamics.

Unit. 2. B-cell biology and antibody 12 h

Immunoglobulin gene rearrangement, class switch and affinity maturation; Selection, maturation and activation of B-cells, germinal center reaction and B-cell memory; Therapeutic antibody: monoclonal antibody and its usage; Antibody engineering: antibody-drug conjugates, bi-specific antibodies, nano-bodies, Bi-specific T-cell Engagers (BiTEs), Camelid antibodies, Chicken IgY.

Unit 3. Cell-mediated immunity **15 h**

Development and maturation of T-cells, epigenetic control; MHC-restriction, T-cell activation: role of co-receptors and co-stimulation in T-cell functioning, Effector functions in cell-mediated immunity: Th populations and their roles in immunity; CTL, Treg and their functioning, T-cell memory, tolerance; Mucosal immunity.

Unit 4. Immunological techniques and application **10 h**

HLA-typing and transplantation; Immunoprecipitation and immunoblotting; Recombinant antibody and hybridoma technology; ELISA, ELISpot, immunohistochemistry and immunofluorescence; Flow cytometry and immunophenotyping, immunomagnetic separation, CAR-T cells and immunotherapy; Vaccine development.

Tutorial **15 h**

Group discussions, presentations and assignments

Essential/Recommended Readings

1. Abbas, Abul K., Lichtman, Andrew H. and Pillai, Shiv (Latest edition). Cellular and Molecular Immunology. Elsevier (Saunders).
2. Murphy, Kenneth M. et al. (Latest edition). Janeway's Immunobiology. W.W. Norton and Company.
3. Punt, Jenni et al. (Latest edition). Kuby Immunology. W.H. Freeman and Company (Macmillan Learning).

Suggestive Readings

1. Flajnik, Martin F. et al. (Latest edition). Paul's Fundamental Immunology. Wolters Kluwer (Lippincott Williams and Wilkins).
2. American Physiological Society. (Latest edition). Handbook of Physiology, Section 7: The Endocrine System. Oxford University Press.
3. Bentley, P. J. (Latest edition). Comparative Vertebrate Endocrinology. Cambridge University Press.
4. Latest research and review papers from Nature, Cell, Immunity, Current Opinions in Immunology, Trends in Immunology, PNAS (USA), and Journal of Immunology.

Discipline Specific Elective-10B (DSE-10B)

MSZOOLE-306: Protein Structure, Function and Evolution

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**	BSc	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Develop an understanding of protein chemistry, structure and folding.
- Students will learn mechanisms of signaling, regulation, protein degradation, and disease relevance, and gain familiarity with key analytical and structural techniques.

Learning outcomes

By studying this course, students will be able to:

- Explain protein structure–function relationships, folding pathways, and evolutionary patterns,
- Analyse signaling mechanisms and post-translational modifications, interpret protein disorder, misfolding, and degradation pathways.
- Critically discuss and apply knowledge of analytical tools and experimental workflows in protein research.

SYLLABUS OF DSE-10B

MSZOOLE-306: Protein Structure, Function and Evolution

Unit 1. Chemical nature of polypeptides 11 h

Classification and chemical nature of amino acids: acid–base and ionisation properties, stereochemistry, and importance of L and D forms, amino acid derivatives; Non-ribosomal peptides; Structure and role of extracellular matrix proteins, glycoproteins, and proteoglycans; Supramolecular protein assemblies: ribosome, chylomicron, and multi-enzyme complexes.

Unit 2. Protein structure, folding and evolution 10 h

Levels of protein structure: primary, secondary, supersecondary, tertiary, and quaternary; Ramachandran Plot; Forces stabilizing protein structure; Protein folding, energy landscapes, molecular chaperones; Intrinsically disordered proteins; Protein families, convergent and divergent evolution of protein structure and functions.

Unit 3. Protein function, dynamics, and regulation 10h

Membrane and intracellular receptors, receptor-ligand interactions, Signal transduction proteins

and pathways: G-proteins, receptor tyrosine kinases, serine/threonine kinases, two-component systems, arginine kinase); Major post-translational modifications and their role in signal regulation; Protein-protein and protein-ligand interaction analysis: Isotherm al titration calorimetry, Surface plasmon resonance, Fluorescence resonance energy transfer, and co-immunoprecipitation.

Unit 4. Protein degradation in health and disease **14 h**

Protein catabolism; Protein degradation and half-life regulation: ubiquitin-proteasome system and autophagy; Protein denaturation, protein aggregation diseases, and prion biology; Genetic disorders affecting protein function; Protein separation and analysis techniques: chromatography, electrophoresis, immunoblotting, enzyme linked immunosorbent assay, mass spectrometry, cryo electron microscopy; Principles of protein engineering and design: site-directed mutagenesis, fusion proteins, and directed evolution; Overview of proteomics.

Practical **30 h**

1. Construction of a peptide chain using ball-and-stick model to understand its molecular characteristics.
2. Estimation of protein concentration using Bradford dye-binding assay.
3. Determination of the isoelectric point of a protein.
4. Estimation of tryptophan and cysteine content by spectrophotometry.
5. Overexpression of recombinant protein and separation on SDS-PAGE.
6. Identification of overexpressed recombinant protein by Western blotting.
7. Purification of overexpressed protein by affinity chromatography.
8. Quantification of the purified protein.

Essential/Recommended Readings

1. Creighton, Thomas E. (Latest edition). Proteins: Structures and Molecular Properties. W.H. Freeman and Company.
2. Voet, Donald, Voet, Judith G. and Pratt, Charlotte W. (Latest edition). Fundamentals of Biochemistry: Life at the Molecular Level. Wiley.
3. Williamson, Michael P. (Latest edition). How Proteins Work. Garland Science (Taylor and Francis).

Suggestive Readings

1. Kessel, Amit and Ben-Tal, Nir (Latest edition). Introduction to Proteins: Structure, Function, and Motion. CRC Press.
2. Hofmann, Andreas and Clokie, Samuel (Latest edition). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.

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 bioinformatics 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.
3. Additional Online Resources: Galaxy Training Materials (training.galaxyproject.org), NCBI Education Resources

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, rodent 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 (Latest Versions/Editions)

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

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 **10h**

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.

SKILL BASED COURSE-3A (SBC-3A)

MS ZOOLS -311: Advanced Laboratory Courses in Genomics (Part I)

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:

- Develop hands-on proficiency in genomic DNA extraction, quality assessment, and preparation of high-quality templates suitable for next-generation sequencing (NGS).
- Perform key wet-lab procedures including PCR amplification and controlled DNA fragmentation (sonication) for library preparation.
- Execute genome assembly and quality evaluation using contemporary bioinformatics pipelines.
- Carry out functional annotation of prokaryotic genomes and generate comparative genomics insights including SNP profiling.

Learning outcomes

By the end of this course, students will be able to:

- Design and implement experimental workflows for whole-genome sequencing from DNA extraction through to template preparation for bulk NGS platforms.
- Apply open-source and web-based bioinformatics tools for de novo genome assembly, quality control, gene prediction, and functional annotation.
- Perform comparative genomic analyses and variant (SNP) detection using standardized platforms such as Galaxy.
- Integrate wet-lab genomics techniques with computational analysis to address real-world biological questions in microbial genomics and related fields.
- Effectively access, utilize, and interpret data from major genomic databases and online analysis resources.

Main Course Structure **60 h**

1. Genomic DNA extraction from bacterial/archaeal sources and quality assessment (spectrophotometry, gel electrophoresis).
2. Fluorimetric quantification of double-stranded DNA (Qubit assay or equivalent).
3. Controlled fragmentation of genomic DNA using sonication (optimization of fragment size for NGS library preparation).
4. Hands-on genome assembly using short-read data (example tools: SPAdes, Unicycler or similar).
5. Quality assessment of genome assemblies (QUAST, BUSCO, read mapping statistics).

6. Functional annotation of assembled genomes using Prokka (gene prediction, tRNA/rRNA annotation with Barrnap).
7. Comparative genomics: assessment of sequence similarity (ANI, OrthoANI, Mash or similar tools).
8. Single Nucleotide Polymorphism (SNP) profile generation and variant calling using the Galaxy webserver.
9. Visualization and interpretation of annotation results (genomic browsers, circular genome plots).

Teaching Methodology/Activities in the classroom: The following methods will be used:

- **Lab demonstrations and hands-on experiments:** Practical sessions with live demonstrations of DNA extraction, and computational analysis using recorded datasets and real laboratory techniques.
- **Data analysis:** Training in bioinformatics workflows using sequencing datasets, including quality control interpretation, assembly evaluation, and presentation of results.

Assessment Pattern for each Unit/practical

Continuous assessment throughout the semester, maintenance of practical records/notebooks, and end-semester practical-based examination.

Mapping with the next suggestive course

Students can build advanced skills by pursuing specialized training in metagenomics, long-read sequencing (Nanopore/PacBio), eukaryotic genome assembly, multi-omics integration (transcriptomics, epigenomics), or population genomics.

Prospective Job Roles

This course develops practical competence in genomic DNA handling, genome assembly/annotation, comparative genomics, and variant analysis, forming a solid foundation for laboratory and computational careers in genomics and bioinformatics.

1. Genomics and bioinformatics lab roles: Genome specialist, NGS laboratory manager, Bioinformatician
2. Research and academic sector: Research Fellow, Genome assembly/Annotation specialist
3. Industry: Biotechnology, Agriculture, Microbiology

Employment Sectors:

- Research institutes and Universities
- Biotechnology and Genomics companies
- Agriculture and Microbial biotech firms
- Clinical diagnostic and public health labs
- Pharmaceutical microbiology departments
- Environmental and food safety genomics labs

Essential/Recommended Readings

1. Sambrook, Joseph and Russell, David W. (Latest edition). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
2. Buffalo, Vince (Latest edition). Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools. O'Reilly Media.

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. Seemann, Torsten (Latest edition). Prokka: Rapid Prokaryotic Genome Annotation. Bioinformatics Journal.
4. Protocols and pipelines from current best practices in microbial genomics (e.g., ASM or ENA documentation).

Skill-Based Course-3B (SBC-3B)

MSZOOLS-312: Advanced Laboratory Courses in Reproductive Technology (Part I)

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:

- To gain practical expertise in maintenance and breeding of rodents and
- To understand the effects of environmental factors on maternal and F1 generation health.

Learning outcomes

By studying this course, students will be able to

- Perform techniques and methodologies essential for understanding complex hormonal regulation of pregnancy and its related disorders.
- Execute protocols to assess the effect of environmental factors on pregnancy outcomes.
- Design and conduct bioassays and biochemical assays to quantify metabolic and reproductive parameters.

Main Course Structure

1. Breeding set up, pregnancy detection, maintenance of rat/mice pups

1.1 Handling of animals and breeding pair set-up
1.2 To identify the first day of pregnancy in rodents.
1.3 Induction of pseudo-pregnancy in rodents.
1.4 Identification of male and female pups and weaning after 21 days of birth.

2. Gross anatomy, topography and histology of rodent reproductive tissues

2.1 Histological Difference in mammary glands of immature, adult and pregnant rodents
2.2 Microscopic changes in ovary and uterus, testis, epididymis, analysis by software.

3. Effect of Environment, Lifestyle and Xenoestrogens

3.1 Epigenetic Effects of environment, lifestyle and xenoestrogens on male and female rats/mice
3.2 Effect of maternal nutrition status on litter size, sex ratio and birth weight of the pups.
3.3 Understanding the impact of abdominal fat on reproductive health

4. Animal Models for pregnancy-related disorders and offspring health

4.1 Effect of endocrine disruptor chemicals (EDCs) such as plastic (BPA) on metabolism in pups
4.2 Impact of valproate-exposed pregnant rats on infant health.
4.3 Proteomic profiling of tissue samples from immature rats/mice after treatments (4.1 and 4.2).
4.4 Effect of maternal diabetes on Leydig cell steroidogenesis in male pups
4.5 Biochemical assay for assessing neurodevelopmental effects in pups of environmentally exposed pregnant rats

Teaching Methodology/Activities in the classroom:

The Following methods will be used:

- **Lab Demonstrations & Hands-on Experiments**: Engage students with hands-on experiments and laboratory techniques related to reproductive technology.
- **Data Analysis**: Statistical Analysis, interpretation and presentation of data generated using hands-on experience and previously available datasets.
- Research project report writing and data analysis for research paper.

Assessment Pattern for each Unit/practical

Continuous assessment throughout the semester, practical records and end-semester practical-based examination.

Mapping with the next suggestive course

The students will get specialised training on laboratory techniques which act as a baseline for molecular endocrinology and reproductive biology courses, industry internship and certificate courses including assisted reproductive technology, embryology and IVF.

Prospective Job Roles

This course leverages skills in handling of rodents and techniques related to accessing maternal and neonatal reproductive health, including breeding, maintenance of pups, histology, proteomic analysis, biochemical assays, gene expression studies, providing a strong foundation for laboratory-based and applied careers in endocrinology and reproductive biology, assisted reproductive technology, embryology, IVF industries, and regulatory compliance.

1. Research Lab Roles including Clinical embryologist, scientific analyst, technician, research fellow.
2. Public Health Laboratory Technician (fertlility montinoring), Hormonal Bioassay Expert; technical positions in ART and IVF clinics, and PhD Research Fellowships.

Employment Sectors:

- Universities, Colleges, Research institutions and Hospitals
- IVF and embryology labs
- Public health departments
- Regulatory agencies and Ministries

Essential/Recommended Readings

1. Calculations for Molecular Biology and Biotechnology, A guide to Mathematics in the Laboratory, Frank H. Stephenson, Applied Biosystems, Academic Press, An Imprint of Elsevier.
2. Chastain, C. B. (Latest edition). Concise Textbook of Small Animal Handling. CRC Press.
3. Strauss, Jerome F. and Barbieri, Robert L. (Latest edition). Yen and Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management. Elsevier.
4. Grattan, David R. and Médina-Gómez, Gema (Latest edition). Neuroendocrine Regulation of Mammalian Pregnancy and Lactation. Springer Nature.
5. Medical Biochemistry Human Metabolism in Health and Disease, Miriam D. Rosenthal Robert H. Glew, Wiley, A John Wiley & Sons, Inc. Publication
6. Flora de Pablo, et al. (Latest edition). Handbook of Endocrine Research Techniques. Academic Press (Elsevier).

Suggestive Readings

1. Gardner, David K. et al. (Latest edition). Textbook of Assisted Reproductive Techniques: Laboratory Perspectives. CRC Press.
2. Kovács, Christopher S. and Deal, Cheri L. (Latest edition). Maternal-Fetal and Neonatal Endocrinology: Physiology, Pathophysiology, and Clinical Management. Academic Press (Elsevier).

SKILL-BASED COURSE-3C (SBC-3C)

MSZOOLS-313: Advanced Laboratory Courses in Entomology (Part I)

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:

- To translate the theoretical frameworks of insect diversity and evolution into a suite of applied research skills.
- To integrate modern digital tools, specifically iNaturalist, to facilitate biodiversity documentation and virtual curation while training students in ethical non-invasive field techniques.
- To enable the students to distinguish between beneficial and harmful insects and providean understanding of the complex caste hierarchies and architectural engineering found in eusocial insect societies.

Learning outcomes

By studying this course, students will be able to:

- Execute professional entomological surveys and morphological assessments by maintaining an authenticated portfolio of local insect fauna.
- Manage zero-mortality sampling protocols and record habitat-specific data, effectively mapping the societal and biological implications of insect populations.
- Apply entomological principles to real-world scenarios, particularly in identifying biocontrol agents and managing biodiversity records.

Main Course Structure **60h**

Morphology:

1. Study of the morphological details of the head and its sclerites of honeybee, grasshopper and cockroach.
2. Study of mouth parts of grasshopper, cockroach, housefly, honeybee, mosquito and butterfly.
3. Types of wings and their venation.
4. Types of antennae and legs in different insects.
5. Study of stinging apparatus of honeybee.

Taxonomy:

6. Application of diagnostic keys for taxonomic classification up to the sub-order level.

7. Methodologies in modern biodiversity documentation: Shifting from physical preservation to digital curation and iNaturalist-based virtual archiving.
8. Field protocols for non-destructive population monitoring: Utilisation of insect traps and observational transects for live study and immediate release.

Social Insects:

9. Morphological and anatomical studies of various castes of *Polistes, Apis, Camponotus, and Odontotermes*.
10. Study of various types of social insects and their nests.

Teaching Methodology/Activities in the classroom:

The following methods will be used:

- Blended learning combining lab demonstrations and hands-on experiments: Demonstration of sclerite boundaries and wing venation patterns in detailusing high-resolution macro-photography and 3D digital models.
- Students will examine live or preserved museum specimens, focusing on the functional mechanics of diverse mouthparts and the stinging apparatus.
- Students will also analyse the sociobiology of insects by mapping caste hierarchies and investigating the engineering principles behind different nest architectures through inquiry-guided group discussions.
- "Virtual insect curation" initiative: Students will utilise modern digital archiving tools such as iNaturalist, to perform field sampling.

Assessment Pattern for each Unit/practical

Continuous assessment throughout the semester, practical records and end-semester practical-based examination.

Mapping with the next suggestive course

Students can enhance their skills by pursuing courses like Insect Physiology, Toxicology of Insecticides, and Insect pests, Disease vectors and Epidemiology helping them get well rounded in their understanding of applied entomology and pest management.

Prospective Job Roles

This course opens possible career opportunities in the research, conservation, and the agriculture sector in roles like entomologist, taxonomist, biodiversity documentation specialist, apiculturist, biological control specialist, etc.

Employment Sectors:

- Research institutes and Universities
- Agriculture departments, ICAR institutes, KVKs, and State Agricultural Universities

- Zoological Survey of India, forest departments, and biodiversity boards
- National Centre for Disease Control (NCDC), vector-borne disease control units, and public health labs
- Apiculture development programmes and commercial honey enterprises
- NGOs and environmental consultancies
- Museums, insectariums, and digital biodiversity platforms

Essential/Recommended Readings

1. Gibb, Timothy J. and Oseto, Christian (Latest edition). Insect Collection and Identification: Techniques for the Field and Laboratory. Academic Press (Elsevier).
2. Crozier, Ross H. and Pamilo, Pekka (Latest edition). Evolution of Social Insect Colonies: Sex Allocation and Kin Selection. Oxford University Press.

Suggestive Readings

1. Grimaldi, David and Engel, Michael S. (Latest edition). Evolution of the Insects. Cambridge University Press.

SKILL-BASED COURSE-3D (SBC-3D)

MSZOOLS - 314: Advanced Laboratory Courses in Fish Biology (Part I)

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:

- Identify fish species using taxonomic keys, DNA barcoding, and molecular tools, including genomic DNA extraction and mitochondrial marker-based phylogenetic analysis.
- Assess fish diversity through ecological indices, species checklists, and analysis of morphometric, meristic, age, and growth parameters.
- Apply DNA barcoding and eDNA approaches for advanced fish biodiversity assessment and monitoring.

Learning outcomes

By studying this course, students will be able to:

- Identify fish species using morphological and molecular approaches, including DNA extraction, molecular validation, and phylogenetic analysis.
- Analyse fish diversity, species composition, and population structure using diversity indices, age, and growth parameters.
- Apply DNA barcoding and eDNA tools for fish biodiversity assessment and monitoring.

Main Course Structure 60h

1. Identification of fish from different water bodies using standard keys and barcodes.
2. Preparation of species checklist, calculation of diversity indices.
3. Estimation of growth parameters and population structure.
4. Morphometric and meristic analysis of fish.
5. Determination of age using different hard parts of fish, otolith, opercular bones, fish scale, and clethra bone.
6. Extraction of genomic DNA from fish tissue.
7. Molecular identification of fishes using molecular markers like COI.
8. Phylogenetic tree construction using online pipelines for fish species delineation.
9. DNA barcoding workflow (data-based/wet lab demonstration).
10. eDNA sampling of water bodies.

Teaching Methodology/Activities in the classroom: The following methods will be used:

- **Laboratory demonstrations and hands-on training:** Students will receive hands-on training in fish identification, morphometric and meristic analysis, and diversity assessment.
- Practical sessions will include age and growth estimation using fish hard parts, genomic DNA extraction, molecular identification using mitochondrial markers, and basic phylogenetic analysis.
- Demonstrations of the DNA barcoding workflow and environmental DNA (eDNA) applications for fish biodiversity monitoring will also be conducted.

Assessment Pattern for each Unit/practical

Evaluation will be based on continuous internal assessment, practical record, and an end-semester examination

Mapping with the next suggestive course

This course provides foundational knowledge and practical skills in fish identification, diversity analysis, and molecular techniques, which prepare students for advanced courses such as Fish Molecular Ecology, Conservation Genetics, and Aquatic Biodiversity Assessment. The training in DNA barcoding, phylogenetic analysis, and eDNA applications equips students to undertake advanced studies in genomics, metagenomics, and fish population genetics for biodiversity monitoring and conservation research.

Prospective Job Roles

- Fishery Biologist
- Aquaculture Specialist
- Fish Taxonomist / Ichthyologist
- Molecular Biologist in Fisheries
- Aquatic Biodiversity Researcher
- Consultant of Aquatic Ecology
- Fish Genetics and Genomics Researcher
- Fisheries Extension Officer
- Research Scientist in Fisheries and Aquatic Sciences

Employment Sectors

- Government Fisheries Departments and Agencies
- Universities and Academic Institutions
- Aquaculture and Fish Farming Industries
- Biotechnology and Molecular Biology Laboratories

- Environmental Monitoring and Consultancy Organizations
- Research Institutes and National Laboratories
- Non-Governmental Organizations (NGOs) working in aquatic biodiversity and conservation
- Private Aquaculture and Fish Health Diagnostic Laboratories

Essential/Recommended Readings

1. Helfman, Gene S. et al. (Latest edition). The Diversity of Fishes: Biology, Evolution, and Ecology. Wiley-Blackwell.
2. Nelson, Joseph S. et al. (Latest edition). Fishes of the World. Wiley.
3. Kocher, Thomas D. and Stepien, Carol A. (Latest edition). Molecular Systematics of Fishes. Academic Press (Elsevier).
4. Kress, W. John and Erickson, David L. (Latest edition). DNA Barcodes: Methods and Protocols. Humana Press (Springer).
5. Pitcher, Tony J. and Hart, Paul J. B. (Latest edition). Fish Population Dynamics. Springer.

Suggestive Readings

1. Talwar, P. K. and Jhingran, Arun G. (Latest edition). Freshwater Fishes of the Indian Region. Narendra Publishing House.
2. Menon, A. G. K. (Latest edition). Inland Fishes of India and Adjacent Countries. Oxford and IBH Publishing.
3. Freeland, Joanna R. et al. (Latest edition). Molecular Ecology. Wiley-Blackwell.
4. Taberlet, Pierre et al. (Latest edition). Environmental DNA: For Biodiversity Research and Monitoring. Oxford University Press.
5. Lesk, Arthur M. (Latest edition). Introduction to Bioinformatics. Oxford University Press.

GENERIC ELECTIVE COURSE 3 (GE-3)

MSZOOLGE-315: Behaviour of Social Animals

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:

- To develop a comprehensive understanding of behavioural science.
- To develop an understanding of the formulation and testing of hypotheses in behavioural science.
- To develop an understanding of behavioural therapy and the importance of the environment.

Learning outcomes

By studying this course, students will be able to:

- The students will understand and appreciate the diverse behaviours of the social animals including humans.
- The students will be able to assess the situation in a gathering and behave accordingly.
- The students will be able to appreciate the mind-body relationship.

SYLLABUS OF GE-3

MSZOOLGE-315: Behaviour of Social Animals

Unit 1. Foundations of Sociality 12 h

Definition of sociality- cost and benefit analysis, Evolutionary drivers of sociality- Group selection vs Natural selection, Reciprocal Altruism, Kin selection and inclusive fitness, eusociality- comparative study of different species; Types of behaviours and interactions among animals; Parental care and its role in evolution of sociality.

Unit 2. The social brain 12 h

Social brain hypothesis and its implications for social evolution; Evolutionary relationships between sociality, cognition and brain size in insects, primates and humans; Interspecies sociality- relation between humans and their domestic animals/pets; Neural basis of social knowledge. The chemistry of connection- role of Oxytocin and Vasopressin in pair-bonding, maternal care, and "in-group" loyalty.

Unit 3. Conflict, Aggression and Hierarchy **12 h**

Conflict and conflict resolution- actual and ritualized combat, assessment of strengths and weaknesses of opponents; agonistic behaviour, submissive behaviour, and dominance hierarchy, implications in antipredatory and reproductive behaviours; pay-off matrix and its importance.

Unit 4. Epigenetics and the Social Interactome **12 h**

Molecular Machinery of Sociality-DNA Methylation and Histone Acetylation, fixed genetic traits and plastic epigenetic responses to social cues; Early life experience and maternal programming; Social status and the immune System; Transgenerational social epigenetics.

Essential/Recommended Readings

1. Tinbergen, Nikolaas (Latest edition). Social Behaviour in Animals. Chapman and Hall.
2. Breed, Michael D. and Moore, Janice (Latest edition). Animal Behavior. Elsevier Academic Press.

Suggestive Readings

1. Neural basis of collective social behavior during environmental challenge. *PMC11429680*.
2. Pilot Study on Epigenetic Response to A Mind-Body Treatment. *PMC6056253*.

Department of Zoology,
University of Delhi, Delhi-110007

MSc. Zoology
PGCF-Structure I: Course work Based 2026
Semester IV

M.Sc. Zoology Course- Semester-IV

Semester IV				
Core Courses (Total number-2)	**Credits in each core course**			
	Theory	**Practical**	**Tutorial**	**Credits**
MSZOOLC-401 Evolutionary Biology	3	1	--	4
MSZOOLC-402 Molecular Cell Biology	3	1	--	4
Total Credits in Core Course	**8**			
Number of Elective Courses (Total number-3) A student has to choose three discipline-specific electives or two discipline-specific electives (one general elective) from the following options:				
Choose 3 DSE from the following DSEs	**Credits in each elective course**			
	Theory	**Practical**	**Tutorial**	**Credits**
Genomics specialization related DSEs				
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 Multiomics	3	--	1	4
Molecular Endocrinology and Reproduction specialization related DSEs				
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
Entomology specialization related DSEs				
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
Fish Biology specialization related DSEs				
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 3 Elective Courses	**12**			
Skill-Based Course: Choose One SBC out of Four				
MSZOOLS-415 **Advanced Laboratory Courses in Genomics (Part II)**	0	2	--	2
MS ZOOLS-416 **Advanced Laboratory Courses in Reproductive Technology (Part II)**	0	2	--	2
MS ZOOLS-417 **Advanced Laboratory Courses in Entomology (Part II)**	0	2	--	2
MS ZOOLS-418 **Advanced Laboratory Courses in Fish Biology (Part II)**	0	2	--	2
Total Credits from SBC	**2**			
General Elective (GE- 4)				
MSZOOLGE-419 **Animal Experimentation and Ethics**	3	--	1	4

Discipline Specific Core-9 (DSC-9)

MS ZOOLC-401: Evolutionary Biology

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:

- Apply principles of population genetics and evolutionary mechanisms to biological problems.
- Analyse and interpret phylogenetic data using morphological and molecular approaches.
- Evaluate evolutionary interactions and life-history strategies in ecological and applied contexts.

Learning outcomes

By studying this course, students will be able to:

- Apply principles of population genetics and Hardy–Weinberg equilibrium to analyze evolutionary change in populations.
- Evaluate ecological and co-evolutionary interactions (e.g., host–parasite, insect–plant, sexual conflict) using evolutionary frameworks.
- Design and interpret basic experimental and computational studies related to natural selection, genetic variation, and evolutionary dynamics.

SYLLABUS OF DSC-9

MS ZOOLC-401: Evolutionary Biology

Unit 1. Overview of evolutionary biology 7 h

History of evolutionary thought– Linnaeus, Dobzhansky, John Ray, Malthus, Lyell, Mendel, Lamarck, Wallace, Darwin, Haeckel, Spencer, Agassiz – understanding evolution, Fisher's genetical theory of evolution; Integration of Mendelian genetics, population genetics and natural selection; Evidence for evolution: biochemical, genetic and fossil.

Unit 2. Evolutionary patterns and processes 19 h

Tree of Life: understanding relationship and Readings trees, phylogenetic tree inference-data sources, role of 16s rRNA, phylogenetic tree analytics - character-based (parsimony) and distance-based (UPGMA) methods, overview of other methods: Likelihood, Bayesian, applications of phylogenetics; Population genetics: variation, Hardy-Weinberg equilibrium,

selection, mutation, genetic drift, migration; Fitness and adaptation; Modes, tempo and isolating mechanisms of speciation.

Unit 3. Evolutionary interactions **10 h**

Coevolution: processes -arms race, red queen, case studies -host-parasite, sexual conflict, insect-plant interactions; Community evolution and multi-species interaction: mutualists, antagonists and competition.

Unit 4. Life history and applications **9 h**

Life history traits, life history theory, trade-offs and constraints; Sexual dimorphism - differential response of males and females; Evolutionary applications: human evolution, evolutionary medicine.

Practical **30 h**

1. Evolution in bacteria using antibiotic selection pressure.
2. Natural selection in *Drosophila* populations.
3. Processes of evolution using the Allele A1 program.
4. Morphology-based phylogenetic tree construction.
5. Construction of phylogenetic trees using sequences of varying lengths.
6. Designing primers for genes of evolutionary importance.
7. Amplification of gene sequence of evolutionary importance by using genomic DNA.
8. Purification of the gene, restriction digestion and SNP identification.
9. Computational simulations to study population dynamics.
10. Coevolutionary interactions using a model host and parasite.

Essential/Recommended Readings

1. Futuyma, Douglas J. and Kirkpatrick, Mark (Latest edition). Evolution. Sinauer Associates (Oxford University Press).
2. Mayr, Ernst (Latest edition). What Evolution Is. Basic Books.
3. Herron, Jon C. and Freeman, Scott (Latest edition). Evolutionary Analysis. Pearson.
4. Stearns, Stephen C. (Latest edition). Evolution in Health and Disease. Oxford University Press.

Suggestive Readings

1. Barton, Nicholas H. et al. (Latest edition). Evolution. Cold Spring Harbor Laboratory Press.
2. Flatt, Thomas and Heyland, Andreas (Latest edition). Mechanisms of Life History Evolution: The Genetics and Physiology of Life History Traits and Trade-Offs. Oxford University Press.
3. Hall, Brian K. and Hallgrímsson, Benedikt (Latest edition). Strickberger's Evolution. Jones and Bartlett Learning.

4. Thompson, John N. (Latest edition). The Coevolutionary Process. University of Chicago Press.
5. Latest research papers published in Evolution, Nature Ecology and Evolution, and Journal of Evolutionary Biology.

Discipline Specific Core-10 (DSC-10)

MS ZOOLC-402: Advanced Cell Biology: Mechanisms, and Systems regulation

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:

- Explain the advances in structure, dynamics, and functional cell biology with emphasis on systems biology
- Describe the translational aspects of mammalian cell cycle, including checkpoints
- Interpret how cells organize into tissues and communicate through extracellular matrix interactions.

Learning outcomes

By studying this course, students will be able to:

- Draw parallels between the physiological processes at the cellular and organismic levels.
- Appreciate the importance of cell-cell adhesion and the extracellular matrix in multicellular organisms.
- Gain advanced knowledge about the techniques and experiments that contributed to the understanding of molecular mechanisms of the cellular processes.

SYLLABUS OF DSC-9

MS ZOOLC-402: Advanced Cell Biology: Mechanisms and Systems regulation

Unit 1. Cellular Organization & Systems Architecture 16 h

Membrane dynamics, phase separation, biomolecular condensates, Organelle communication (ER–mitochondria, nucleus–cytoplasm), Cellular Dynamics: Cell Cycle Control, Cyclins, CDKs, checkpoints (G1/S, G2/M), DNA damage response (p53, ATM/ATR), Cell cycle dysregulation in cancer, Quiescence vs senescence; Cytoskeleton: Actin, microtubules, intermediate filaments, Cell motility and intracellular transport, mechano-transduction; Chromatin organization: euchromatin vs heterochromatin, Transcriptional regulation networks, RNA processing, alternative splicing, Epigenetics: DNA methylation, histone modification, ncRNA (miRNA), 3D genome organization.

Unit 2. Inter- and intra-cellular communication: **10 h**

Cell-cell and cell-matrix adhesion; Cell junctions; Cell Signaling Networks: Signal transduction logic (amplification, feedback), GPCR, RTK, steroid signaling pathways, Crosstalk between pathways, Temporal vs spatial signaling dynamics. Desensitization of receptors; Drugs and addiction mechanisms involving receptor expression.

Unit 3. Cell Death and Survival Mechanisms: **9 h**

Cellular Stress & Environmental Responses, Oxidative stress, hypoxia, metabolic stress, ROS signaling vs damage, Apoptosis, necrosis, autophagy, Ferroptosis, pyroptosis, ER stress & unfolded protein response (UPR), Protein folding and chaperones, Ubiquitin–proteasome system, Autophagy vs proteasomal degradation, Environmental toxicology at cellular level, Mammalian cell culture and cytotoxicity.

Unit 4. Translational Cell Biology: **10 h**

Cell biology of diseases, Cell death in disease (cancer, neurodegeneration), Drug targeting at cellular level especially in cancer cells: Cytoskeletal remodeling in metastasis, Systems biology & precision medicine, Stem Cells & Cellular Reprogramming: Stem cell potency (totipotent-multipotent), Niche signaling, Induced pluripotent stem cells (iPSCs), Epigenetic reprogramming.

Practical **30 h**

1. Membrane permeability assay: Dye uptake (trypan blue / propidium iodide)
2. Cell culture and evaluation of aseptic technique using microbial fingerprinting to assess the efficiency of 70% ethanol disinfection.
3. Isolation of functional mitochondria from liver tissue by differential centrifugation.
4. Determination of protein concentration in the subcellular fractions using Lowry's method.
5. Osmotic stress assay: Cell swelling/shrinkage kinetics, Red blood cell lysis assay
6. Identification of mitochondrial fraction by assay of marker enzyme.
7. Assessment of proliferation/cytotoxicity by MTT assay.

Essential/Recommended Readings

1. Lodish, Harvey et al. (Latest edition). Molecular Cell Biology. W.H. Freeman and Company.
2. Alberts, Bruce et al. (Latest edition). Molecular Biology of the Cell. W.W. Norton and Company.
3. Weaver, Robert F. (Latest edition). Molecular Biology. McGraw-Hill Education.

Suggestive Readings

1. Cooper, Geoffrey M. and Hausman, Robert E. (Latest edition). The Cell: A Molecular Approach. Sinauer Associates (Oxford University Press).
2. Karp, Gerald et al. (Latest edition). Karp's Cell and Molecular Biology. Wiley.

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_0), 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.

SKILL BASED COURSE-4A (SBC-4A)

MS ZOOLS-415: Advanced Laboratory Courses in Genomics (Part II)

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.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- Understand the principles of DNA quantification
- Quantify double-stranded DNA libraries and perform real-time PCR-based quantification of next-generation sequencing libraries.
- Isolate and analyze chromatin components
- Prepare libraries for long-read sequencing and analyze sequencing data.

Learning outcomes:

By studying this course, students will be able to:

- Students will be able to quantify DNA libraries, isolate and characterize chromatin components, and prepare libraries for long-read sequencing using various techniques and technologies.
- Students will be able to analyze sequencing data, including aligning reads against a reference genome and interpreting aligned data and apply bioinformatics tools for data analysis.

Main Course Structure **60 h**

1. To quantify double-stranded DNA libraries using the Qubit Fluorimeter with the Qubit dsDNA HS assay kit.
2. To perform real-time PCR–based quantification of next-generation sequencing libraries using the NEBNext® Library Quant Kit for Illumina®.
3. Isolation of nuclei (as a source for studies on the structure of chromatin) from rat/mouse liver by discontinuous sucrose-density gradient centrifugation.
4. Isolation of total histones and resolution on SDS-PAGE.
5. Methylation-specific PCR and study of promoter hypermethylation.
6. To gain hands-on experience in loading and washing of Oxford Nanopore MinION FlowCells.
7. To understand and execute library preparation workflows for long-read sequencing (LRS) using Oxford Nanopore Technologies.
8. To perform plasmid library preparation and multiplexing using the Oxford Nanopore Rapid Barcoding Kit.
9. To assemble plasmid sequencing reads using the EPI2ME analysis platform.
10. To perform read alignment against a reference genome using appropriate tools for different sequencing platforms -MiniMap2 for long-read data and STAR for short-read data.

11. To analyze and interpret aligned sequencing data using the R software.

Teaching Methodology/Activities in the classroom: The following methods will be used:

- **Lab demonstrations and hands-on experiments:** Practical sessions with live demonstrations of DNA and histone extraction, NGS library preparation and its estimation, long-read sequencing and its instrumentation, associated computational analysis using new or recorded datasets.
- **Data analysis:** Training in bioinformatics workflows using sequencing datasets, including quality control interpretation, assembly evaluation, and presentation of results.

Assessment Pattern for each Unit/practical

Continuous assessment throughout the semester, maintenance of practical records/notebooks, and end-semester practical-based examination.

Mapping with the next suggestive course

Based on the exposure and expertise gained through comprehensive set of exercises will assist the students to undertake advanced hands-on exercises in NGS, industry-relevant certifications (e.g., Galaxy/NCBI workshops), and research internships. The course will prepare students for roles in microbial, clinical andenvironmental genomics, biotech R&D, and academic research.

Prospective Job Roles

This course develops practical competence in generating and interpreting genomic data. The expertise gained in DNA handling, genome assembly/annotation, comparative genomics, and variant analysis (Galaxy) will build a foundation for laboratory and computational careers in genomics and bioinformatics.

- Genomics and bioinformatics lab roles: Genome specialist, NGS laboratory manager, Bioinformatician
- Research and academic sector: Research Fellow (Genomics), Genome assembly/Annotation specialist
- Industry: Biotechnology, Agriculture, Microbiology

Employment Sectors:

- Research institutes and Universities
- Biotechnology and Genomics companies
- Agriculture and Microbial biotech firms
- Clinical diagnostic and public health labs
- Pharmaceutical microbiology departments
- Environmental and food safety genomics labs

Essential/Recommended Readings

1. Sambrook, Joseph and Russell, David W. (Latest edition). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
2. Ausubel, Frederick M. et al. (Eds.) (Latest edition). Current Protocols in Molecular Biology. John Wiley and Sons.

3. Oxford Nanopore Technologies. (Latest edition). Oxford Nanopore Technologies User Manual. ONT.
4. Pevsner, Jonathan (Latest edition). Bioinformatics and Functional Genomics. Wiley-Blackwell.
5. Abril-Pla, Oriol and Román-Mallarino, Lorena (Latest edition). R Bioinformatics Cookbook. Packt Publishing.

Suggestive Readings

1. Thermo Fisher Scientific. (Latest edition). Qubit Fluorometer User Manual. Thermo Fisher Scientific.
2. New England Biolabs. (Latest edition). NEBNext Library Quant Kit for Illumina User Manual. New England Biolabs.
3. Oxford Nanopore Technologies. (Latest edition). Oxford Nanopore MinION User Manual. ONT.

SKILL BASED COURSE-4B (SBC-4B)

MS ZOOLS-416: Advanced Laboratory Courses in Reproductive Technology (Part II)

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.	-	Zoology

Learning objectives

The learning objectives of this course are as follows:

- To gain hands-on practical expertise in understanding biochemistry and functions of endocrine hormones in the maintenance of reproductive health.
- To understand how environmental stressors affect fertility.

Learning outcomes:

By studying this course students will be able to:

- Perform bioassays for different hormones.
- Quantify hormones and investigate their biological activities.
- Understand the effects of contraceptive drugs, endocrine disruptors on reproductive functions.

Main Course Structure **60 h**

1. In vitro biochemical assay for a hormone (LH or PRL).
2. Isolation of protein hormone (FSH and LH) and demonstration of bioactivity in an in vivo bioassay.
3. In vivo bioassay for estrogen or testosterone.
4. Effect of hCG on RNA content in ovary.
5. Quantitation of specific transcript (mRNA) after ovarian stimulation by hCG or FSH.
6. ELISA for any one hormone and estimation of plasma level.
7. Streptozotocin-induced rat model for diabetes.
8. Estimation of weight or biochemical parameter in a rat tissue (e.g. adipose, ovary, uterus).
9. Effects of environmental endocrine disruptors (BPA) on fertility after exposure at immature, young and adult rats/mice.
10. To study the effect of known contraceptive drugs on the histology of the testis or ovary of adolescent and young rats/mice.
11. Effect of environmental factors/pollution on pregnancy in rats/mice.
12. Proteomic analysis of the placenta in rat/mice.

Teaching Methodology/Activities in the classroom: The following methods will be used:

- **Lab Demonstrations & Hands-on Experiments**: Engage students with hands-on experiments and laboratory techniques including biochemical assay, hormonal quantification and hormone bioassays related to molecular endocrinology and reproduction.
- **Data Analysis**: Statistical Analysis, interpretation and presentation of data generated

using hands-on experience and previously available datasets.

Assessment Pattern for each Unit/practical.
Continuous assessment throughout the semester, practical records and end-semester practical-based examination.

Mapping with the next suggestive course
The students will get specialised training on laboratory techniques to prepare them for careers in clinical embryology. Internship and certificate courses such as nutrition and endocrinology, dietitian, diabetes care specialist, endocrine counsellor, assisted reproductive technology, embryology, IVF and PhD programme.

Prospective Job Roles
This course leverages skills in handling rodents and techniques related to assessing maternal and neonatal reproductive health, including breeding, maintenance of pups, histology, proteomic analysis, biochemical assays, hormonal assays, gene expression studies, providing a strong foundation for laboratory-based and applied careers in endocrinology and reproductive biology, assisted reproductive technology, embryology, IVF industries, and regulatory compliance.

Prospective job roles:

- Analytical and Research Lab Roles, including scientific data analyst, technician, research fellow.
- Public Health and Research: Public Health Laboratory Technician (fertlility montinoring), Hormonal Bioassay Expert; technical positions in ART and IVF clinics, and PhD Research Fellowships.

Employment Sectors:

- Research institutes and Universities
- IVF and embryology labs
- Pharmaceutical and Biotech Industry
- Public health department
- Regulatory agencies

Essential/Recommended Readings

1. Flora de Pablo, Colin G. Scanes, Bruce D. Weintraub (Ed.). (1993). Handbook of Endocrine Research Techniques. Academic Press/Elsevier
2. Infertility from Basics to Advanced Reproductive Technology", Evangel publications (In association with FOGSI, India), ISBN: 9788197821660.
3. Introduction to Biostatistics and Research Methods, Fourth Edition, P. S. S. Sunder Rao, J. Richard, Prentice- Hall of India Private Limited.
4. Calculations for Molecular Biology and Biotechnology, A guide to Mathematics in the Laboratory, Frank H. Stephenson, Applied Biosystems, Academic Press, An Imprint of Elsevier.

5. Methods in Molecular Biology-58, Basic DNA and RNA Protocols, Adrian J. Harwood, MRC Laboratory for Molecular Cell Biology, London, UK, Humana Press, Totowa, New Jersey.

Suggestive Readings

1. Lavin (Ed.). (2018). Manual of Endocrinology and Metabolism. Wolters Kluwer.
2. Receptor Signal Transduction Protocols, R. A. J. Challiss, University of Leicester, UK, Humana Press, Totowa, New Jersey.

SKILL BASED COURSE-4C (SBC-4C)

MS ZOOLS-417: Advanced Laboratory Courses in Entomology (Part II)

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:

- Develop analytical proficiency in detecting and quantifying pesticide residues using chromatographic and spectrophotometric techniques (TLC, GLC, HPLC).
- Perform toxicological assessments through bioassays and enzyme inhibition studies to evaluate the physiological impact of xenobiotics.
- Assess the environmental behaviour of pesticides by estimating dissipation rates and half-lives in soil.
- Conduct genetic toxicology assays (Ames test, mitotic index, micronuclei) to evaluate mutagenic and clastogenic risks.

Learning outcomes

By studying this course, students will be able to:

- Execute toxicological protocols and interpret data related to chemical exposure and environmental contamination.
- Perform residue analysis on soil, water, and food samples using chromatographic and spectrophotometric instrumentation for safety and compliance assessments.
- Design and conduct insect-based bioassays and biochemical assays to quantify toxicity and pesticide-induced molecular disruptions.
- Model environmental persistence of contaminants by calculating degradation constants, half-lives, and evaluating genotoxic and mutagenic risks through standardized tests.

Main Course Structure **60 h**

1. Pesticide residue analysis of contaminated soil, vegetables and water using spectrophotometry, TLC, GLC and HPLC.
2. Estimation of LD_{50} and LC_{50} by conducting bioassays on insects.
3. Studies on the dissipation of pesticides from soil and half-life estimation.
4. Assessment of the genotoxic effect of pesticides through the mitotic index and the micronuclei test.
5. Assessment of pesticide induced mutations using Ames test.
6. Estimation of acetylcholinesterase activity to evaluate the toxicity of xenobiotic compounds.
7. Histological analysis of the insect alimentary canal using H&E staining.
8. Visualisation of the effect of hormonal control on molting and metamorphosis.
9. Determination of an insect's Respiratory Quotient (RQ).

Teaching Methodology/Activities in the classroom: The following methods will be used:

- **Demonstrations and hands-on experiments**: Engage students with practical demonstrations using previously recorded data and real laboratory techniques.
- **Data analysis** using real datasets to enhance analytical skills including interpretation and presentation of results.

Assessment Pattern for each Unit/practical.

Continuous assessment throughout the semester, practical records and end-semester practical-based examination.

Mapping with the next suggestive course

Students can enhance skills by pursuing specialised training in regulatory toxicology, advanced analytical methods (LC-MS/GC-MS), and ecotoxicology/biomonitoring, which build on this course's lab competencies through hands-on progression, industry certifications, and internships. These pathways prepare students for regulatory, research, and public health roles in food quality and pollution control.

Prospective Job Roles

This course leverages skills in pesticide residue analysis, bioassays, enzyme inhibition studies, environmental persistence modelling, and genetic toxicology assays, providing a strong foundation for laboratory-based and applied careers in toxicology, environmental monitoring, and regulatory compliance. The students will be competent for jobs in:

1. Analytical and toxicology laboratories: Pesticide Residue Analyst, Toxicology Research Assistant, Laboratory Technician (GLC/HPLC), Genetic Toxicology Technician
2. Regulatory and environmental sector: Regulatory Toxicology Assistant, Environmental Compliance Officer, Pollution Control Analyst
3. Public health and research: Public Health Laboratory Technician (pesticide monitoring), Insecticide Bioassay Specialist; technical positions in food quality assessment, pollution control labs and PhD Research Fellowships.

Essential/Recommended Readings

1. Oberdorster, Eva (Latest edition). Toxicology Laboratory Lab Manual. Kendall Hunt Publishing Company.
2. Wilson, K., Hofmann, A., Walker, J. M., & Clokie, S. (Eds.). (Latest edition). Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge university press.
3. Lakhotia, Subhash C. and Ranganath, H. A. (Latest edition). Experiments with Drosophila for Biology Courses. Indian Academy of Sciences.

Suggestive Readings

1. Proudlock, Robert (Latest edition). Genetic Toxicology Testing: A Laboratory Manual. Academic Press (Elsevier).

SKILL BASED COURSE-4D (SBC-4D)

MS ZOOLS-418: Advanced Laboratory Courses in Fish Biology II

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

- Advanced, research-oriented understanding of fish biology.
- Integrate classical ichthyology with genomics and multi-omics tools.
- Explore fish environment interactions, health, and antimicrobial resistance.
- Examine climate change impacts on aquatic biodiversity.
- Prepare students for independent research and careers in fisheries and molecular fish science.

Learning outcomes

By studying this course, students will be able to:

- Explain fish diversity, evolution, and functional adaptations.
- Analyse fish–environment interactions and anthropogenic impacts.
- Apply molecular and omics tools in fish research.
- Interpret microbiome and antimicrobial resistance data.
- Design, analyse, and critically evaluate scientific research.

Main Course Structure 60 h

1. Isolation of genomic DNA from water and GI tract of fish for metagenomics.
2. Fish gut microbiome data analysis (Amplicon Specific Variants / shotgun datasets).
3. Histological slide preparation of different fish tissues.
4. Population modelling using R.
5. Metabolomic profiling of fish tissue using LC-MS and NMR.
6. Physico-chemical analysis of effluent and polluted water.
7. Preparation of fish feed.
8. Identification and analysis of feed ingredients
9. Feed formulation for Fishes
10. Feeding trials with Indian Major Carps (IMCs) and ornamental fishes
11. Measurement of growth parameters and feed utilization
12. Data analysis and interpretation of feeding experiments
13. Diagnosis of fish diseases of the Indian major carp.
14. Visit to a fish farm to understand the induced breeding of Indian major carps.
15. Maintenance of aquarium fishes, their breeding and care.

Teaching Methodology/Activities in the classroom: The following methods will be used:

- **Laboratory Demonstrations and Hands-on Training:** Students will receive practical training in wastewater quality analysis and hands-on exposure to advanced analytical instruments commonly used in fisheries research.
- A field visit will be organised to demonstrate the induced breeding techniques of Indian Major Carps. Participants will also be trained in scientific formulation and preparation of fish feed for different feeding habits.
- In addition, in silico analysis of shotgun metagenomic datasets, along with data interpretation and biological inference, will be conducted to provide exposure to modern multi-omics approaches in fisheries research.

Assessment Pattern for each Unit/practical.

Evaluation will be based on continuous internal assessment, practical performance, and an end-semester examination

Mapping with the next suggestive course

Students can strengthen their competencies by undertaking specialized training in advanced molecular and analytical tools applied in fisheries research. This includes hands-on expertise in physico-chemical analysis of water quality, assessment of primary productivity, quantification of heavy metals using Atomic Absorption Spectroscopy (AAS), and detection of organic and inorganic pesticides through LC-MS and GC-MS techniques. Training in comprehensive environmental and contaminant assessment in aquatic ecosystems using FTIR, EDX, and mass spectrometry, will help students enhance their skills.

Prospective Job Roles

- Fish taxonomist
- Research Associate / Project Scientist
- Analytical Chemist/Metabolomics Analyst
- Environmental Toxicology Analyst
- Food Safety Analyst/Quality Control (QC) Officer
- Lab Manager – Advanced Instrumentation

Employment Sectors

- ICAR Institutes, CSIR Labs, DBT funded centers
- Universities/ Colleges/Schools
- FSSAI labs
- Pharmaceutical companies
- Environmental testing labs
- Private metabolomics & proteomics facilities

Essential/Recommended Readings

1. Lipps, William C. et al. (Latest edition). Standard Methods for the Examination of Water and Wastewater . APHA, AWWA, WEF. (The definitive manual for water chemistry and quality testing).
2. Noga, Edward J. (Latest edition). Fish Disease: Diagnosis and Treatment. Wiley-Blackwell. (A clinical "how-to" for identifying pathogens in the lab).
3. ICAR. (Latest edition). Handbook of Fish Farming: Aquaculture Practical and Hatchery Manuals. Indian Council of Agricultural Research. (Standard operating procedures for Indian aquaculture systems).
4. Halver, John E. and Hardy, Ronald W. (Latest edition). Fish Nutrition. Academic Press (Elsevier). (Essential for lab-based feed analysis and diet formulation).
5. FAO. (Latest editions). FAO Aquaculture Technical Manuals. Food and Agriculture Organization. (Practical, step-by-step guides for pond construction and seed production).

Suggested Readings

1. Lekang, Odd-Ivar (Latest edition). Aquaculture Engineering. Wiley-Blackwell. (Practical guide for designing filtration, aeration, and recirculating systems).
2. Roberts, Ronald J. (Latest edition). Fish Pathology. Wiley-Blackwell. (The standard reference for histopathology and tissue processing).
3. Stickney, Robert R. (Latest edition). Aquaculture: An Introductory Text. CABI Publishing. (Strong focus on the practical biological requirements of farmed species).
4. Goddek, Simon et al. (Eds.) (Latest edition). Aquaponics Food Production Systems. Springer. (Detailed technical specs for building integrated systems).
5. Moyle, Peter B. and Cech, Joseph J. (Latest edition). Fishes: An Introduction to Ichthyology. Pearson. (Used specifically for morphological identification and dissection protocols).

GENERIC ELECTIVE COURSE-4 (GE-4)

MS ZOOLGE-419: Animal Experimentation and Ethics

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

Course Objectives

This course aims to familiarize students with

- Commonly used animal models and their applications in biological, chemical, pharmaceutical, toxicological and environmental research.
- Experimental design and modern alternatives to animal use.
- The course introduces ethical considerations.

Learning Outcomes

Upon successful completion of the course, students will be able to

- Understand the concept of animal models in scientific research.
- Identify commonly used vertebrate and invertebrate model organisms.
- Explain how animal models contribute to chemistry, environmental science, plant sciences and medicine.
- Appreciate ethical principles governing animal experimentation.
- Understand emerging alternatives including organoids, computer modelling and cell culture.

SYLLABUS OF GE-4

MS ZOOLGE-419: Animal Experimentation and Ethics

UNIT I

Introduction to Animal Models 13 h

Introduction to animal use for experimentation, Historical development of animal models, importance of animals in scientific research, Selection of appropriate animal models; Classification of Animal Models, Vertebrate models, Invertebrate models; Natural versus induced disease models, Transgenic and knockout animal models (basic concepts)

UNIT II **12 h**

Characteristics of an Animal Model

Common Experimental Animals: Mouse, Rat, Rabbit, Zebrafish, Fruit fly (Drosophila), Nematode (Caenorhabditis elegans); Similarity to humans, Ease of maintenance, Reproducibility, Cost-effectiveness; Applications of Animal Models, Biomedical Research, Pharmaceutical Research, Environmental Sciences, Chemical Sciences, Plant Sciences, Animal Models in Disease Research: Neurodegeneration (Alzheimer's, Parkinson's), Developmental defects, Immunity and infection

UNIT III **10 h**

Ethics, Animal Welfare and Alternatives

Ethics in Animal Research, Need for ethical use of animals, Animal welfare concepts, The 3Rs Principle (Replacement, Reduction, Refinement); Animal Care, Housing, Nutrition, Environmental enrichment, Humane endpoints; Regulatory Framework, CCSEA guidelines (India), Institutional Animal Ethics Committee (IAEC), OECD toxicity guidelines (basic overview)

UNIT IV **10 h**

Future of research using animal models

Historical role in biomedical research. Strengths and limitations, Cell culture systems and immortalised lines. Stem cells and regenerative biology. Organoids for disease modelling. Organ-on-chip microfluidic systems, Computer simulations and computational biology, and artificial intelligence. Modern Applications of Animal Models: Bioindicators in environmental monitoring, High-throughput screening for drug testing, Humanoid models and robotics in physiology.

Tutorials / Assignments **15 h**

Students will undertake activities such as:

- Seminar on a model organism
- Case study on drug discovery
- Review of a drug using an animal model
- Debate on animal ethics
- Critical analysis of a published research paper
- Poster presentation
- Virtual laboratory exercises

Case Studies

- Animal models used in COVID-19 research
- Animal models in cancer research
- Animal models for endocrine disruptors
- Animal models in vaccine development

Suggested Demonstrations (Non-animal)

- Identification of common laboratory animal models using photographs/specimens
- Virtual animal facility tour
- Observation of zebrafish or Drosophila developmental stages (video demonstrations)
- Visit to animal House and Introduction to CCSEA documentation
- Demonstration of animal handling videos (without live handling)
- Computer-based simulations of toxicity studies
- Data interpretation from published animal experiments

Suggested Reading

1. Hau J, Schapiro SJ. Handbook of Laboratory Animal Science. CRC Press.
2. Fox JG, Anderson LC, Otto GM, Pritchett-Corning KR, Whary MT. Laboratory Animal Medicine. Academic Press.
3. Festing MFW, Baumans V. The Design and Statistical Analysis of Animal Experiments.
4. Russell WMS, Burch RL. The Principles of Humane Experimental Technique.
5. CPCSEA. Guidelines for Laboratory Animal Facility. Government of India.
6. OECD. Guidelines for the Testing of Chemicals.
7. Suckow MA, Stevens KA, Wilson RP. The Laboratory Rabbit, Guinea Pig, Hamster, and Other Rodents.