Department of Zoology, University of Delhi

UNIVERSITY OF DELHI
MASTER OF ZOOLOGY
(MSZOOL)
(Academic Year 2025)

PROGRAM BROCHURE

Syllabus under NEP2020 Frame work
For the First Year of M.Sc. Zoology to be effective from 2025

CONTENTS

Department of Zoology, University of Delhi

1. About the Department

The Department of Zoology, established in 1947, has consistently upheld its commitment to excellence in teaching and research in animal sciences. In 1963, it was recognized as the Centre for Advanced Studies (CAS) in Endocrinology and Cell biology, a status it continues to enjoy to this day. The Department's dedication to excellence is further demonstrated by its state-of-the-art Central-Instrument Facility (CIF), funded by the University, DST-Purse and DST-FIST grants, DBT, ICAR and ICMR extramural grants.

Over its 78-year history, the Department of Zoology has achieved significant milestones. It has produced post-graduate students and awarded doctoral degrees. The academic training provided to the Department's M.Sc. students prepares them for doctoral programs at leading institutes globally. The Department's alumni have made significant contributions in diverse fields, serving as faculty and scientists at renowned universities and research institutes worldwide, and as distinguished officers in government services and biotechnology industries.

The current research and teaching in the Department include diverse aspects of Zoology with a balance of organismic and reductionist biology. It offers teaching and interdisciplinary research programs in the diverse areas such as, Reproductive Biology, Molecular Endocrinology, Genomics, Metagenomics, Cancer Biology, Animal Physiology, Entomology, Fish Biology, Immunology, Developmental Biology, Cell Biology, and Radiation Biology. The faculty members have been publishing scientific papers in peer-reviewed high-impact research journals.

The Department of Zoology, a world-class center of excellence in Zoology education, and advanced research training, envisions promoting self sustainability and innovation in students through skill development. The Department is committed to impart a holistic understanding of Zoology, thereby 'redefining Zoology' for the modern student, enhancing their employability, and fostering an interest in and innovative solutions for biodiversity conservation and the promotion of a physiologically and mentally healthy society. To further strengthen its academic and research capabilities, the Department is currently undertaking major renovations of its teaching and research laboratories. The M.Sc. curriculum has also been revised in alignment with the National Education Policy (NEP) 2020 to better reflect the Department's evolving vision and mission.

With a rich history, the Department of Zoology remains unwavering in its commitment to advance scientific excellence and societal relevance.

II. Introduction to NEP 2020

National Education Policy (NEP) 2020

The courses are restructured to promote interdisciplinary learning, research-driven education, and flexible curriculum design. Emphasis is placed on skill development, critical thinking, and experiential learning, aligning with global standards and industry needs. The revised framework encourages academic mobility, while integrating modern pedagogical approaches and digital tools. This reform, in line with the NEP 2020, aims to enhance student employability, innovation, and holistic understanding of the subject.

Definitions:

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii) 'Course' means a segment of a subject that is part of an Academic Programme.

(iii) 'Programme Structure' means a list of courses (Core, Elective, General Elective, Skill-based Course) that makes up an academic programme, specifying the syllabus, credits, hours of teaching, evaluation and examination scheme, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University rules, eligibility criteria for admission.

(iv) 'Core Course" means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

(vi) PG 'General Elective' means an elective course which is available for students of all programs other than students of same department. Students of other Department will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(viii) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(ix) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) 'Grand CGPA' is calculated in the last year of the two-year course by clubbing together the CGPA of two years, i.e., four semesters. This cumulative grade point average, presented in the form of a Transcript, is a comprehensive reflection of the student's academic performance throughout the program. To benefit the student, a formula for converting the Grand CGPA into percentage marks is provided in the Transcript, aiding in their future academic and career pursuits.

Programme Objectives (POs):

The M.Sc. Zoology program is designed to provide students with an in-depth and interdisciplinary understanding of animal and human life. It covers a wide range of topics, from cellular and molecular processes to recent advances in Zoology, from organismic to reductionist biology. The course is structured to build strong foundational knowledge through core subjects such as Comparative Animal Physiology, Genetics and Cytogenetics, and Principles of Gene Manipulation. It also offers flexibility through a range of elective courses that address current and emerging areas in Zoology—including Animal Behaviour, Chronobiology, Metabolic Diseases, and One Health. This interdisciplinary approach opens up diverse learning opportunities and excites students about the breadth of knowledge they will gain.

The program places a strong emphasis on both theoretical learning and practical skill development. With dedicated laboratory sessions and a specialized skill-based course, students are ensured hands-on training in modern biological techniques. By integrating traditional zoological studies with cutting-edge scientific advancements, the program aims to cultivate critical thinking, scientific inquiry, and research competencies. This approach instills confidence in students, preparing them for careers in academic research, teaching, biotechnology, healthcare, environmental management, and public policy, and laying a strong foundation for pursuing doctoral studies and other advanced scientific careers.

Programme Specific Outcomes (PSOs):

The M.Sc. Zoology program will equip students with advanced knowledge and practical expertise in the biological sciences, with a specific focus on animal physiology, genetics, molecular biology, and ecological health. Upon successful completion of the program, students will be able to critically analyze and interpret complex biological phenomena, understand the genetic and cellular basis of life, and apply molecular tools in gene manipulation. Through elective courses, they gain specialized insights into emerging areas such as Animal behavior, Chronobiology, Metabolic disorders, and the One Health approach, enabling them to address real-world challenges in human, animal, and environmental health. The program also fosters proficiency in laboratory techniques, data analysis, and scientific communication through intensive hands-on-training. Thereby, students are well-prepared for careers in research, teaching, biotechnology, public health, and conservation, and are equipped to pursue doctoral studies or professional roles requiring interdisciplinary and research-oriented skills.

Selection of Elective Courses:

Elective courses in Zoology-

The number of seats in each elective course would be limited and will be announced before the commencement of the course in each year. The selection of elective papers in 1st and 2nd Semesters shall be based on merit criteria decided by the Academic committee of the Department.

Eligibility for Admissions:

This course is open to students who have studied Zoology, Biological Sciences or Life Science in B.Sc. based on an entrance test. Please refer to the rules of University of Delhi for seats and the procedure for admission.

'Assessment of Students' Performance and Scheme of Examination:

Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the University of Delhi. English shall be the medium of instruction and examination.

III. M.Sc. Zoology Programme

First Year of the two-year **M.Sc. Zoology** program is divided into two semesters. The **Details of the papers are as follows**

SEM.	Discipline Specific Core (DSC) (4x3=12 credits)	Discipline Specific Elective(DSE)/ General Elective Course (GE) DSE and GE (4x2=8 Credits) 2 DSE or 1 DSE+1 GE	SKILL BASED COURSE /SPECIALISED LAB (2 Credits)	Dissertation	TOTAL CREDITS
I	**[DSC-1]** Comparative Animal Physiology **[DSC-2]** Genetics and Cytogenetics **[DSC-3]** Principles of Gene Manipulation	**[DSE-1 & 2]** 1. Animal Behaviour 2. Chronobiology 3. Life Style and Metabolic Diseases 4. One Health: Principles and Applications [GE-1] 1. Endocrine Disruptors and Neural Pathways	Specialized Laboratory course in Zoology Part I	NIL	22
II	**[DSC-4]** Developmental Biology **[DSC-5]** Metabolism: Concepts and Regulation **[DSC-6]** Immunology	**[DSE-3 & 4]** 1. Cancer Biology 2. Neurobiology 3. Biology of Parasitism 4. Pharmacognosy and Basics of Traditional Medicine [GE-2] 1. Animal Models in Research	Specialized Laboratory course in Zoology Part II	NIL	22

Course Credit Scheme

Sem.	Discipline Specific Core(DSC)			Discipline Specific Elective(DSE)/ General Elective Course (GE)			Skill Based Course			Total Credits
	No.of papers	Credits (L+P)	**Total Credits**	No.of papers	Credits (L+T)	**Total Credits**	No.of papers	Credits (L+P)	**Total Credits**	
I	3	9L+3P	**12**	2	6L + 2T	**8**	1	2P	**2**	**22**
II	3	9L+3P	**12**	2	6L + 2T	**8**	1	2P	**2**	**22**
Total Credits	6	18L+6P	**24**	4	12L+4T	**16**	2	4P	**4**	**44**

For each Discipline Specific Core Courses, there will be 3 lecture hours of teaching (3 credit) and practical will be two hours (1 credit) every week.

For Discipline Specific Elective Courses and General Elective Courses (4 credit each), there will be 3 lecture hours of teaching and 1 Tutorial every week.

For Skill Based Courses (2 credit), there will be four hours of practical every week.

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Semester wise Details of M.Sc. Zoology Course-Semester I

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 thepaper number.				
SemesterI				
Number ofcorecourses	**Creditsineachcorecourse**			
Course	Theory	Practical	Tutorial	Credits
MSZOOLC-101 Comparative Animal Physiology	3	1	-	4
MSZOOLC-102 Genetics and Cytogenetics	3	1	-	4
MSZOOLC-103 Principle of Gene Manipulation	3	1	-	4
3 Core courses	9	3	-	12
Total credits in core courses	**12**			
Number of elective courses Astudent hastochoose two DSE or one DSE and one GE fromthefollowingoptions	**Creditsineach Electivecourse**			
	Theory	Practical	Tutorial	Credits
Discipline specific elective (DSE)				
MSZOOLE-104 Animal Behaviour	**3**		**1**	**4**
MSZOOLE-105 Chronobiology	**3**		**1**	**4**
MS ZOOLE-106 Life Style and Metabolic Diseases	**3**		**1**	**4**
MS ZOOLE-107 One Health: Principles and Applications	**3**	-	**1**	**4**
General elective (GE-1)				
MS ZOOLGE-108 Endocrine Disruptors and Neural Pathways	**3**		**1**	**4**
Total credits from 2 elective courses	**8**			
Credits in skill based Course	Theory	Practical	Tutorial	Credits
Skill based course (SBC) **MSZOOLS-109** Specialized Laboratory course in Zoology Part I	-	2	-	2
Total credits in 1 Skill based course	**2**			

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Discipline Specific Core-1 (DSC-1): MS ZOOLC-101

Comparative Animal 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.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To develop a comprehensive understanding of how physiological processes, vary across different animal species and how these processes are adapted to diverse environments.
- To understand the modifications/adaptations found in different physiological systems of various organisms.
- The course also has a strong lab component, where students will develop skills in designing and conducting physiological experiments, recording accurate observations, and analyzing data.

Learning Outcomes

By studying this course, students will be able to:

- Develop a comprehensive understanding of the physiology of invertebrate and vertebrate animals.
- Understand how different physiological environments have shaped the physiology of animals across the animal kingdom
- Appreciate how different environmental conditions (e.g., temperature, oxygen availability, salinity) have shaped the physiological adaptations of various animal groups.

SYLLABUS OF DSC-1: Comparative Animal Physiology

MS ZOOLC-101

Unit 1. Internal transport and gas exchange **9 h**

Circulation: Systems of circulation, peripheral circulation, regulation of heart beat and blood pressure; Respiration: Transport and exchange of gases, neural and chemical regulation of respiration, gas transfer in air and water, gas exchangers, regulation of body pH.

Unit 2. Adaptations to stress **12 h**

Basic concepts of stress; Osmoregulation: Osmoregulation in aquatic and terrestrial environments, extra-renal osmoregulatory organs; Thermoregulation: Heat balance in animals, adaptations to temperature extremes, torpor, aestivation and hibernation, counter current heat exchangers; Bioluminiscence

Unit 3. Sensing the environment and coordination **13 h**

Sensory perception: Photoreception, chemoreception, mechanoreception; Chromatophores: Types, functional modifications and regulation, behavioural significance; Feeding: Modes, habits and patterns of feeding, behavioral adaptation

Unit 4. Muscle physiology **11 h**

Muscle structure and energetics, muscle adaptations; Electric organs: electroplaxes, electric discharge, and functional significance

Practical **30 h**

1. Study the concentration of pigment in isolated scales of dark-adapted fish.
2. Study the dispersal of pigment in isolated scales of light-adapted fish.
3. Examine the relative activity of enzymes in the fore, mid, and hindgut of a typical insect and correlate the enzyme activity with the different gut regions.
4. A comparative study of age-related variability in plethysmographic measurements
5. Observe and compare the inherent rhythmicity of the different parts of the heart.
6. Determine the effects of application of parasympathetic or sympathetic agonists/antagonists.
7. Assessing physical and chemical modifiers of heart rate in frog.
8. Determine the response of the heart to direct electrical stimulation / vagal stimulation.
9. Determine the threshold concentration of sucrose for eliciting feeding behavior in housefly.

Essential/Recommended Readings

1. Comparative Animal Physiology, Prosser,C.L.& Brown Jr.,F.A.(ed.), Saunders. (latest edition)
2. Eckert: Animal Physiology 5th Ed by Randall, David, Burggern, Warren, French, Kathleen (latest edition)
3. Animal Physiology; Hill,R.W, Wyse,G.A. and Anderson,M. Oxford University Press (latest edition)

Suggested Readings

1. Animal Physiology: Adaptation and Environmental, Nelson K. S. (ed.) Cambridge University Press, Cambridge, UK
2. General and Comparative Animal Physiology, Hoar W. S. (ed.), Prentice Hall, India
3. Comparative Physiology (Handbook of Physiology): Vol. 1, 2, Dantzler, W.H. (ed.) Oxford University Press, New York, USA.
4. Latest research papers published in Comparative Biochemistry and Physiology – Part A and Part B, Journal of Comparative Physiology – Part A and Part B, Journal of Experimental Biology

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Discipline Specific Core-2 (DSC-2): MS ZOOLC-102

Genetics and Cytogenetics

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:

- Genetics and Cytogenetics course includes understanding of chromosome structure, function and their role in inheritance and disease.
- This course will provide a comprehensive understanding of principles of Genetics with a better understanding to analyze complex traits and further implement their use in breeding and selection studies.
- The modern genetic tools for genetic manipulations will be employed to investigate and address genetic diseases.
- Hands-on experience of the students using model organisms will further strengthen their understanding for Genetics.
- By this comprehensive understanding, students can appreciate role of Genetics and Cytogenetics in various fields including disease, medicine, agriculture, biotechnology etc.

Learning Outcomes

- Genetics and Cytogenetics course will open up several avenues for students in terms of research and employability.
- By observing genetic mutations in *Drosophila*, the students can correlate phenotype with genotype, understand genetic interaction and their molecular basis.
- Students will be able to set hands on genetic crosses to understand recessive and dominant, segregation, pattern of inheritance and finally evaluating statistical significance by counting the progeny as statistical analysis provides crucial insights into many biological processes.
- Students will learn how genetic information is passed on in eukaryotes and prokaryotes, how genes work together in a complex manner in biological system and any alteration can lead to major phenotypic change.
- Students will be able to implement modern genetic tools in understanding and mitigating human genetic diseases through genetic counseling, gene therapy etc.

SYLLABUS OF DSC-2: Genetics and Cytogenetics

MS ZOOLC-102

Unit 1. History of genetics and genetic mapping **8 h**

Mendel's principles and its extension: incomplete dominance, co-dominance, penetrance, expressivity, epistasis and pleiotropy; Allelic series, Testing gene mutations for allelism; Fine structure of gene; Methods of gene mapping: Mapping in *E.coli* and its phage, recombination, 3-point test cross; Genetic and physical maps.

Unit 2. Genemutations and regulation of gene expression **12 h**

Types of gene mutations, methods for detection of induced mutations; Transposable elements and their applications; Chromosome structure: Nomenclature, polytene and lampbrush chromosomes and their relevance; Chromosomal abnormalities, Prokaryotic gene regulation:*lac* and *trp* operons of *E. coli;* Eukaryotic gene regulation: Chromatin organization and gene expression, transcription factors, enhancers and silencers, non-coding genes.

Unit 3. Analysing inheritance patterns **13 h**

Inheritance: independent assortment, linkage; Linkage disequilibrium; Pedigree analysis in humans; Complex pattern of inheritance, metric traits or continuous traits, partitioning of phenotypic variance, additive variation; Heritability, artificial selection, breeding value.

Unit 4. Sex determination, dosage compensation and human genetics **12 h**

Sex determination and mechanisms of dosage compensation: Human, *Drosophila* and *C. elegans*; Genetic basis of diseases in humans (Syndromes/Cancer/Infertility); Gal4-UAS system

Practical **30 h**

1. Study of mutant phenotypes of *Drosophila*.
2. Demonstration of law of segregation and independent assortment using *Drosophila* mutants
3. Study of autosomal and sex- linked inheritance using *Drosophila* mutant lines
4. Statistical analysis of genetic crosses
5. Empirical assessment of dosage compensation using *white apricot* (w^a) mutation in *Drosophila*
6. Targeted expression of genes using Gal4 - UAS System in *Drosophila*
7. Preparation and detailed observation of polytene chromosome from *Drosophila* salivary gland.
8. Study of transcriptional activity in polytene chromosome of *Drosophila* upon heat shock.
9. Preparation and study of metaphase chromosomes: Chromosome banding (C, G, H banding).
10. Simulation of genetic crosses using DrosophiLabprogram/Classic Genetics Simulator

Essential/Recommended Readings

1. Snustad and Simmons (Latest edition): Principles of Genetics, John Wiley & Sons, USA
2. Griffiths, J.F., Gilbert, M., Lewontin, C. and Miller, W. H. (Latest edition): Modern Genetic Analysis: Integrating Genes and Genomes, Freeman and Company, New York, USA
3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., Killian, D. (Latest edition) Concepts of Genetics. United Kingdom: Pearson.

Suggestive Readings

1. Herron, Jon C., Freeman, Scott. (Latest edition): Evolutionary Analysis: Pearson Education.
2. Brooker, R. J. (Latest edition). Genetics: Analysis and Principles. United Kingdom: McGraw-Hill Education.
3. Latest research papers published in Genetics, Molecular Genetics, Journal of Genetics, Trends in Genetics

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Discipline Specific Core-3 (DSC-3): MS ZOOLC-103

Principles of Gene Manipulation

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:

- Major objective of this core paper is to introduce to the students, contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organism.
- Lectures will specifically address the historical and standard techniques, gradual evolution and context-dependent applications of molecular techniques for their extended use.
- The student should be able to understand standard and system-specific gene manipulation approaches ranging from bacteria to mammals.

Learning Outcomes

- After successful completion of the course, the students will be able to design and comprehend experimental strategies for alteration of genes and gene products in different organisms.
- Proper understanding of the principles of recombinant DNA techniques will enable the student to design and develop modern recombinant drug molecules and vaccines, thus increasing their employability in the future.

SYLLABUS OF DSC-3: Principles of Gene Manipulation

MS ZOOLC-103

Unit 1. Basic recombinant DNA techniques: **11 h**

Nucleic acid isolation and basic analysis, cutting and joining DNA molecules, restriction modification systems, enzymes used in recombinant DNA technology; Restriction maps and mapping techniques; Nucleic acid probes, blotting techniques, DNA fingerprinting, Gel shift assay; Polymerase chain reaction: methods and applications.

Unit 2. Basic biology of vectors and cloning strategies **12h**

Plasmids, phages, single stranded DNA vectors, high-capacity vectors, expression vectors; Gene cloningstrategies: methods of transforming bacteria with rDNA methods of selection and screening of transformed bacteria; Construction of genomic and cDNA libraries.

Unit 3. Sequencing methods **11 h**

Principles of DNA sequencing, automated sequencing methods; Synthesis of oligonucleotides, primer designing; Directed evolution; Protein engineering.

Unit 4. Manipulating genes in animals **11 h**

Gene transfer to animal cells; Genetic manipulation of animals: transgenic animals, gene knockouts, gene silencing; Genome editing: gene therapy, CRISPR-Cas.

Practical **30 h**

1. Primer designing
2. Polymerase Chain Reaction
3. DNA gel electrophoresis
4. Purification of DNA from an agarose gel
5. Vector and insert ligation
6. Preparation of competent cells and storage
7. Transformation of *E. coli* with recombinant plasmids
8. Calculation of transformation efficiency
9. Plasmid DNA isolation: minipreps
10. DNA quantification and assessment of DNA quality
11. Restriction enzyme digestion
12. Confirmation of ligation in plasmid by different methods

Essential/Recommended Readings

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA (Latest edition).
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (Latest edition), Blackwell Publishing, West Sussex, UK.

Suggestive Readings

1. Molecular Biotechnology: Principles and application of recombinant DNA, Bernard R. and Jack, ASM Press, Herndon, USA (Latest edition).
2. Latest research papers published in Nature Biotechnology, Nature Protocols, Gene Therapy

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Discipline Specific Elective-1 (DSE-1): MS ZOOLE-104

Animal Behavior

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

CREDIT	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 understand the adaptive significance of behavior in different environments.
- To discover how animals communicate, seek food, escape predators, and live together.

Learning Outcomes

- By studying this course, students will have a deep understanding of how and why animals behave the way they do.
- Students will be able to explain the role of brain, hormones, genes, and environment in shaping behavior, and how behavior evolves in response to ecological pressures.

SYLLABUS OF DSE-1: Animal Behaviour

MS ZOOLE-104

Unit 1. Concepts, genetics and physiology of behaviour **14 h**

Understanding animal behaviour from arthropods to vertebratesOntogenetic and phylogenetic approaches: Genetics of behaviour; Interactive theory of behaviour; Experience and development of behaviour; Tracing the evolutionary development of behaviour; Physiological basis of behaviour; Homeostasis: Behavioural strategies for maintaining internal balance; Time management: allocation of time to various activities and its adaptive significance.

Unit 2. Cognition, communication, navigation and foraging **16 h**

Problem-solving abilities and decision-making processes; Comparative cognition across species; Information use and signaling: visual, auditory, chemical and tactile; Evolution and function of signaling systems, sensory exploitation and signal receivers; Locomotion strategies, migration patterns and orientation mechanisms; Risk assessment and food selection; Optimal foraging theory.

Unit 3. Parental care and defense mechanisms **7 h**

Parental investment: Nesting behaviours and territoriality; Anti-predator behaviour: Camouflage, mimicry, and escape strategies; Diversity of anti-predator adaptations.

Unit 4. Reproductive behaviour and conservation **8 h**

Sexual selection and reproductive strategies, mate choice and competition; Role of animal behaviour in protecting biodiversity; Human – wildlife interface; Extinction; Reserve design: captive breeding and reintroductions.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Breed, M.D., & Moore, J. (2021). *Animal Behavior* (Latest edition). Academic Press.
2. Kappeler,PM. (2021). Animal Behavior: an Evolutionary perspective, (Latest edition)Springer
3. Rubenstein, D.R., &Alcock, J. (2019). Animal Behavior (Latest edition). Oxford University Press.
4. Goodenogh, J., McGuire,B. and Jakob,E. (2010). Perspectives on Animal Behavior (Latest edition). Wiley publications.

Suggestive Readings:

1. McFarland, D. (1999) Animal Behavior (Latest edition). Longman press
2. Latest research papers published in Animal Behaviour and Cognition, Journal of the Experimental Analysis of Behaviour, Ethology, ecology and Evolution

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Discipline Specific Elective -2 (DSE-2): MS ZOOLE-105

Chronobiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

CREDIT	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

- To enable students to understand the importance of internal timing in regulating daily and seasonal processes in organisms.

Learning Outcomes

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

- Conceptualize how species profitably inhabit the temporal environment and space out their activities at different times of the day and seasons.
- Understand the molecular, cellular and systems levels of the generation and coordination of internal timing?
- Develop a critical viewpoint and to interpret observations from experiments on biological rhythms regulating daily and seasonal biology.
- Plan studies on biological rhythms in both human and non-human species.
- Understand the consequences of the disruption of internal rhythms on work performance and health in the modern world.

SYLLABUS OF DSE-2: Chronobiology

MS ZOOLE-105

Unit 1. Introduction of Chronobiology and Neural mechanisms of sleep 13 h

History and milestones; Clock, rhythm and calendar; The biological timing system: Concepts and methods; Types of rhythms.Sleep mechanism; Brain rhythm and sleep; Rapid Eye Movement (REM), Non REM; Influence of sleep on memory.

Unit 2. Rhythm characteristics and factors 7 h

Free running rhythm; Entrainment and masking in the natural and artificial environment: Zeitgebers: Photic and non-photic, Parametric and non-parametric entrainment, Phase shift, Phase response curves (PRC) and phase transition curves (PTC); Proximate and ultimate factors; Circannual control of seasonal processes; Photoperiodism: Concepts and photoperiodic time measurement models, Seasonal processes and photoperiodic control mechanisms.

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Unit 3. Organization of the circadian system in multicellular organisms **12 h**

Concept of central and peripheral clock systemsRetinal and pineal clocks; Melatonin: Input and output of the clock system; Anatomy of the circadian clock: suprachiasmatic nucleus (SCN).

Unit 4. Circadian timing , Biological clock, Life style and health **13 h**

Genes and proteins involved in circadian rhythm generation; Molecular feedback loops: Transcription, translation, posttranslational mechanisms; Circadian timing in diverse organisms (*Drosophila*, zebrafish, birds, and mammals). Role of Biological clocks in human health and diseases; Clock dysfunction and lifestyle-related disorders; Chronotherapy.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. (Latest edition). Oxford University Press.
2. Physiology in Sleep (Latest edition) By John Orem. Academic press

Suggestive Readings

1. Insect Clocks ((Latest edition) : D.S. Saunders, C.G.H. Steel, X. Afopoulou (ed.) R.D. Lewis. 2002 Barens and Noble Inc. New York, USA
2. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
3. Circadian Medicine: Christopher Colwell (ed.) Wiley-Blackwell (Latest edition)
4. Circadian Physiology: Roberto Refinetti, CRC Press (Latest edition) 2016
5. Latest research papers published in Chronobiology International, Journal of Biological Rhythms, Journal of Pineal Research

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Discipline Specific Elective (DSE-3): Lifestyle and Metabolic Diseases

MS ZOOLE-106

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

- Understand the biological and environmental foundations of metabolic disorders.
- Explore the role of gut health, diet, physical activity, and circadian rhythms in metabolic regulation.
- Analyze environmental and lifestyle risk factors influencing chronic diseases.
- Evaluate public health strategies and interventions for metabolic health promotion.

Learning Outcomes

By studying this course, students will be able to:

- Describe key metabolic disorders and their underlying mechanisms.
- Explain the impact of gut microbiota, nutrition, sleep, and stress on metabolism.
- Assess lifestyle and environmental interventions for preventing and managing metabolic disorders.
- Propose evidence-based public health and community approaches for metabolic disease prevention.

SYLLABUS OF DSE-3: Lifestyle and Metabolic Diseases

MS ZOOLE-106

Unit 1. Foundation of metabolic health and disorder **12 h**

Introduction to metabolism and metabolic homeostasis; Overview of major metabolic disorders: Obesity, Type 2 Diabetes, Non-alcoholic fatty liver disease (NAFLD), polycystic ovary syndrome (PCOS); Metabolic Syndrome: Role of insulin resistance, inflammation, and oxidative stress.

Unit 2. Gut health, microbiota, and the gut-brain axis **11 h**

The human gut microbiota; Gut dysbiosis and its association with metabolic disorders; Gut-brain axis: links to mood, appetite, immunity, and metabolic balance; Role of diet, antibiotics, and environmental factors in shaping the microbiome; Maintenance of gut health: Probiotics, prebiotics, synbiotics, postbiotics, and Fecal Microbiota Transplantation (FMT).

Unit 3. Environment and health **11 h**

Nutrition and personalized diets; Physical activity:, metabolic benefits, and behavioural strategies; Sleep hygiene, circadian rhythm, and metabolic health; Stress, cortisol, and metabolic implications; Environmental risk factors: pollution, endocrine-disrupting chemicals, microplastics, , air quality; Role of digital health tools and lifestyle tracking in metabolic diseases.

Unit 4. Public health approaches and ccommunity health frameworks **11 h**

Global burden of metabolic disorders (WHO, Sustainable development goals); Workplace, school-based, and community lifestyle programs; Policy frameworks and health promotion strategies; Climate change, metabolic stress, and sustainability; Life-course approach to Non-Communicable Disease prevention; Challenges in global health implementation and intervention scaling.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Lustig, R. (2021): Metabolical: The Lure and the Lies of Processed Food, Nutrition, and Modern Medicine. Harper Wave.
2. Rippe, J. M. (2019): Lifestyle Medicine. CRC Press.
3. Walker, M. (2017): Why We Sleep: Unlocking the Power of Sleep and Dreams. Scribner.
4. Sonnenburg, J., &Sonnenburg, E. (2015): The Good Gut: Taking Control of Your Weight, Your Mood, and Your Long-Term Health. Penguin Press.
5. World Health Organization (Various Years): Global Status Reports on Noncommunicable Diseases (WHO Publications).

Suggested Reading

1. Latest research papers published inNature Metabolism, The Lancet Diabetes & Endocrinology, Frontiers in Nutrition.

Department of Zoology, University of Delhi

Discipline Specific Elective-4 (DSE-4): MS ZOOLE-107

One Health: Principles and Applications

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:

- Interpretation of one health and significance of different players of one health.
- Develop a systems thinking in understanding disease emergence, transmission and mitigation.
- Provide knowledge of drivers of one health and understanding the necessity of multi-faceted strategies in controlling drivers.
- Impact of environmental changes, policy, governance, and community engagement on infectious disease prevention and control.
- Comparative account of immune mechanisms of humans, animal and insects

Learning Outcomes

By studying this course, students will be able to:

- Understand 'One health' approach and its applications.
- Understand the emergent need of one health application in mitigating diseases.
- Explain the role of distinct drivers of one health?
- Demonstrate comprehensive knowledge of risk factors, mode of transmission, and appropriate strategies to alleviate them.
- Discuss drivers of disease emergence and re-emergence.
- Understand and appreciate the complexity of prevalence of antimicrobial resistance.
- Deploy good practices in surveillance, data collection, management and its analysis.
- Understand the principles of effective communication and its relevance in public health and disease mitigation.

SYLLABUS OF DSE-4: One Health: Principles and Applications

MS ZOOLE-107

Unit 1: Foundations of one health **6 h**

Introduction to one health, Overview of infectious, emerging and re-emerging infectious diseases; Drivers and factors in disease emergence: Anthropogenic and environmental drivers, microbial evolution and adaptation.

Unit 2: Disease emergence, transmission, immune response **16 h**

Zoonoses: emergence and spillover mechanisms, reservoirs, vectors, and environmental drivers; Food- and water-borne diseases, Case studies: COVID-19, cholera, tuberculosis; Immune responses in humans and

reservoir hosts; Immunoprophylaxis and immune modulation strategies; Role of insect vectors in zoonotic disease transmission and immune interactions.

Unit 3: Antimicrobial resistance (AMR), environment, surveillance, diagnosticsand analysis 15 h

Drivers of AMR in humans, animals and environment; Environmental factors: climate change, urbanization, land use; One health approaches to AMR mitigation; One health surveillance:Types and goals, integrated disease surveillance systems (human, animal, environment); Diagnostic methods: microbiology, molecular, serology, genomics; Data management.

Unit 4: Policy, Governance, Communication and Future Challenges 8 h

One health governance: Global and National strategies, multi-sectoral coordination and communication mechanisms; Policy development; Community engagement; Emerging threats: bioterrorism, climate-driven diseases, Operational and Governance challenges, Technology and strategic innovations; Issues beyond infectious diseases: pollution, food security, sustainable development goals; Case studies.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Ronald Atlas and Stanley Maloy (Latest edition): One Health: People, Animals, and the Environment. ASM Press
2. Yamada, A., et al. (Latest edition) Confronting Emerging Zoonoses: The One Health Paradigm. 2014. (Eds) Springer, New York, NY
3. Mackenzie, J.S., et al (Latest edition) One Health: The Human-Animal-Environment Interfaces in Emerging Infectious Diseases. Springer, New York, NY
4. Zinsstag, Z., et al (Latest edition) One Health: The Theory and Practice of Integrated Health Approaches. CABI Digital Library

Suggestive Readings

1. Rabinowitz, Peter M. et al (2009) Human-Animal Medicine: Clinical Approaches to Zoonoses, Toxicants and Other Shared Health Risks. Saunders: Elsevier Press, New York
2. David Quammen (2012) Spillover: Animal Infections and the Next Pandemic. 2012. WW Norton and Company. New York
3. Natterson- Horowitz, et al (2013) Zoobiquity: The Astonishing Connection Between Human and Animal Health. Vintage Press
4. WHO: One health initiative
5. Latest research papers published in Nature Microbiology, Applied and Environmental Microbiology, One Health

Department of Zoology, University of Delhi

General Elective-1 (GE-1): MS ZOOLGE-108

Endocrine Disruptors and Neural Pathways

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	4	Nil	Nil	B.Sc.	Nil	Zoology

Course Objectives:

- To enable students to understand how exposure to environmental toxicants and hazardous chemicals in our day-to-day lives can affect human health, with major emphasis on endocrine dysfunction and mental health.
- To make the students understandrequirement of sustainable development of chemicals involved in domestic, agriculture and health sector.

Learning Outcomes

By studying this course, students will be able to:

- The students would understand the environmental toxicants and their effect on hormone action in brain, sex differentiation, behavior, and cognition.
- Know the harmful effects of Plastics and plasticizers on reproductive and metabolic health.
- The students would be able to conceptualize and understand the endocrine effects ofBisphenol A on human physiology.
- Understand the emergent need of discontinuation of plastics and other endocrine disrupting chemicals.
- The students would understand how plastics and alcohol use during pregnancy can affect the brain differentiation during gestation and childhood.
- Understand the effect of drug consumption during adolescence on brain.
- A key outcome is that the students would understand the requirement of sustainable development of chemicals in domestic, agriculture and health sector.

SYLLABUS OF GE-1: Endocrine Disruptors and Neural Pathways

MS ZOOLGE-108

Unit 1. Introduction to the endocrine system **8 h**

Human endocrine system, Types of hormones and their functions in regulation of human physiology.

Unit 2. Endocrine disruptors **11 h**

Historical perspective of endocrine disrupting chemicals (EDCs), Types of EDCs such as Atrazine, Bisphenol A (BPA), Dioxins, Perchlorate, Per- and polyfluoroalkyl substances (PFAS), Phyto and xenoestrogens, Polybrominated diphenyl ethers (PBDE), phthalates, Polychlorinated biphenyls (PCBs), Triclosan, and their sources; Mechanisms of action of endocrine disruptors

Unit 3. EDCs and the nervous system **11 h**

Impact of alcohol, drugs, plastic (BPA) and smoking on neuronaldevelopment and function, Neurodevelopmental disorders and neurological dysfunction associated with EDCs such as autism, dementia, Alzheimer's, Parkinson's, attention-deficit/hyperactivity disorder (ADHD), and learning disability.

Unit 4. Plastics:Endocrine diseases,sexual differentiation of brain and behaviour **15 h**

Impact of BPA, plasticizers, xenoestrogens on gonadal development, sex determination, puberty onset, brain development and behaviour. Impact of plastics (bisphenol isoforms, phthalates) and polyvinyl chloride (PVC) on the development and progression of obesity, metabolic dysfunction, PCOS/PCOD, diabetes, cancer, infertility, puberty, and endometriosis.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Heather B. Patisaul and Scott M. Belcher: Endocrine Disruptors, Brain, and Behavior (2017, Oxford University Press)
2. Philippa D. Darbre (Editor) Endocrine Disruption and Human Health (2021, Academic Press)

Suggestive Readings

1. Kabir, E. R., Rahman, M. S., & Rahman, I. (2015). A review on endocrine disruptors and their possible impacts on human health. Environmental toxicology and pharmacology, 40(1), 241–258. https://doi.org/10.1016/j.etap.2015.06.009
2. Schug, T. T., Johnson, A. F., Birnbaum, L. S., Colborn, T., Guillette, L. J., Jr, Crews, D. P., Collins, T., Soto, A. M., VomSaal, F. S., McLachlan, J. A., Sonnenschein, C., &Heindel, J. J. (2016). Minireview: Endocrine Disruptors: Past Lessons and Future Directions. Molecular endocrinology (Baltimore, Md.), 30(8), 833–847.
3. Latest research papers published in Frontiers in Endocrinology, Journal of Endocrinology, Trends in Endocrinology and Metabolism

Department of Zoology, University of Delhi

Skill Based Course-1 (SBC-1): Specialized Laboratory Course in Zoology Part I
MSZOOLS-109

Course title and Code	Credits	Credit distribution of the course			Eligibility Criteria	Prerequisite of the Course (if any)
		Lecture	Tutorial	Practical		
MSZOOLS-109	2	0	0	2	B.Sc.	Nil

1. Learning Objectives

- Apply observational and experimental techniques (e.g., ethograms, maze learning tasks, mirror tests) to study animal cognition, learning, and social behavior.
- To enable students to understand the rhythmic regulation of internal timing in regulating daily and seasonal processes in organisms.
- Understand key lifestyle contributors (diet, sleep, stress, and activity) to metabolic disease development.
- Develop hands-on expertise in environmental and microbiological techniques, gain proficiency in applying epidemiological models and analyzing infectious disease transmission.
- Learn to collect, analyze, and interpret data.
- Gain hands-on experience with dataset analysis using bioinformatics tools.

2. Learning Outcomes

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

- Students will critically evaluate the role of genes, environment, and evolution in shaping behaviors like courtship in Drosophila or foraging in birds using behavioral ecology principles
- Develop a critical viewpoint and interpret observations from experiments on biological rhythms regulating daily and seasonal biology.
- Identify and understand the complex relationships between lifestyle patterns and metabolic diseases.
- Develop practical skills in isolating and profiling antimicrobial resistance in bacteria from environmental samples, and applying simulation tools to model infection dynamics within the One Health framework.

3. Main Course Structure

Module 1 **30h**

Section A: Animal Behaviour

1. Genetic basis of courtship behavior in *Drosophila.*
2. Evaluate learning and problem-solving using simple maze.
3. Testing self-recognition in fish.
4. Ethogram of *Macacamuleta*, foraging behaviour of birds.

Section B: Chronobiology

5. Ambulatory blood pressure monitoring and circadian analysis.
6. Quantifying oscillations: phase, period and amplitude.
7. Analysis of actograms.
8. Experiments demonstrating the photoperiodic clock.

Module 2 **30h**

Section A: Lifestyle and Metabolic Diseases

1. Meta-analysis of gut microbiota datasets using online tools. Compare the gut microbiome compositions in healthy vs. disease states.
2. Design and analyze a survey assessing risk factors for obesity, type 2 diabetes, and PCOS/PCOD.
3. To investigate Myeloperoxidase (MPO) activity in ovarian and/or uterine tissues of normal, high-fat diet-induced, and PCOS-induced rats/mice as a biochemical marker of inflammation.
4. To evaluate and compare the antioxidant capacity of serum and/or tissue homogenates from normal, high-fat diet-fed, and PCOS-induced rats/mice using the Ferric Reducing Antioxidant Power (FRAP) assay.

Section B: One Health: Principles and Applications

5. *E.coli* sampling from water sample for assessment of Antimicrobial Resistance (AMR) prevalence in the environment.
6. Morphological characterization of microbes.
7. Simulation of infection transmission.
8. One health puzzle to mimic the decision-making process in disease control.

4. Teaching Methodology/Activities in the classroom: Following methods will be used:

- **Lab Demonstrations & Hands-on Experiments**: Engage students with practical demonstrations using previously recorded data and real laboratory techniques to reinforce theoretical concepts.
- **Field-Based Learning**: Provide experiential learning opportunities through field visits and on-site investigations.
- **Group Discussions & Role-Playing**: Foster critical thinking and communication skills through collaborative discussions and simulated real-world scenarios.
- **Simulation Software**: Utilize digital tools to model biological and epidemiological processes, enhancing understanding of complex systems.
- **Data Analysis**: Teach analytical skills by working with real datasets, including interpretation and presentation of results.
- **Case Studies**: Apply knowledge to real-life scenarios, encouraging problem-solving and decision-making.

5. Assessment Pattern for each Unit/practical. Component of Attendance in the Assessment of 1 credit theory course

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

6. Mapping with the next suggestive course

- Advanced courses in Molecular Pathophysiology of Lifestyle Diseases, Translational Microbiome Research, Nutritional Genomics and Personalized Medicine, Applied Ethology, Sleep can enhance skills and employment opportunities.
- Additional certifications in Geographic Information System (GIS), data analysis tools, or entomology can further expand employment opportunities.

7. Prospective Job Roles after a particular course

This course prepares students for a wide range of entry-level roles in public health, research, laboratory science, data analysis, health communication, and program support. Graduates can contribute to disease surveillance, outbreak response, laboratory diagnostics, health education, and research in both human and animal health sectors.

Students can find employment in the following roles:

1. Clinical & Laboratory Roles: Clinical Research Assistant, Biomedical Technician, Laboratory Assistant, Field Investigator (disease tracking, outbreak response), Lifestyle Disease Health Coach
2. Public Health Sector: Public Health Program Coordinator, Infection Prevention Support (hospital or community settings), Mosquito/Insect Control Program Assistant (vector identification and control)
3. Science Communication & Education
4. Data analysts in biomedical and public health sector

Employment Sectors:

- Government health departments,
- NGOs and non-profit organizations
- Hospitals and healthcare facilities, Research institutions and academic labs
- International organizations (e.g., WHO, FAO, OIE)

8. Essential Reading

1. Breed, M.D., & Moore, J. *Animal Behavior* (Latest edition). Academic Press.
2. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. (Latest edition). Oxford University Press.
3. Hu, F. B. Obesity Epidemiology. Oxford University Press
4. Laboratory manuals for biochemical techniques.
5. One Health Cases: CABI Digital Library
6. One Health Puzzle: Life Sciences Learning Center: University of Rochester Medical centre

9. Suggestive Reading

1. McFarland, D. (1999) Animal Behavior (Latest edition). Longman press
2. Circadian Physiology: Roberto Refinetti, CRC Press (Latest edition) 2016
3. WHO and NIH reports on lifestyle-related non-communicable diseases.
4. WHO: One health initiative

Semester wise Details of M.Sc. Zoology Course- Semester II

SemesterII				
Numberofcorecourses	**Creditsineachcorecourse**			
Course	Theory	Practical	Tutorial	Credits
MSZOOLC-201 Developmental Biology	3	1	-	4
MSZOOLC-202 Metabolism: Concepts and Regulation	3	1	-	4
MSZOOLC-203 Immunology	3	1	-	4
Core course 3 (total number)	9	3	-	12
Total credits in core course	**12**			
Number of elective courses	**Credits in each elective course**			
A student has to choose two discipline specific elective or one discipline specific elective and one general elective from the following options:	Theory	Practical	Tutorial	Credits
Discipline specific elective				
MSZOOLE-204: Cancer biology	3		**1**	4
MSZOOLE-205: Neurobiology	3		**1**	4
MS ZOOLE-206: Biology of Parasitism	3		**1**	4
MS ZOOLE-207: Pharmacognosy and Basics of Traditional Medicine	3	-	**1**	4
General elective				
MS ZOOLGE-208: Animal Models in Research	3		1	4
Total credits in 2 elective courses	**8**			
Credits in Skill based course	Theory	Practical	Tutorial	Credits
Skill based course: **MSZOOLS-209** Specialized Laboratory course in Zoology Part II	-	2	-	2
Totalcreditsin1Skill based course	**2**			

Department of Zoology, University of Delhi

Discipline Specific Core-4 (DSC-4): MS ZOOLC-201

Developmental 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:

- This course aims to understand how organisms develop from a single cell to multicellular organism.
- A fundamental concept of development like cell differentiation, organogenesis and involvement of multiple molecular and genetic mechanisms in the process will enable a clear understanding of such complex phenomena.
- Additionally, they will explore how alteration in any of normal developmental process can lead to serious diseases like birth defects, tumor pathogenesis, neurodegenerative disorders etc.
- Hand-on training using different model organisms with significant homology with Human will further strengthen and connect theoretical understanding of students.

Learning outcomes

- A key learning outcome of developmental biology is to understand how organisms develop from a zygote into complex multicellular organisms.
- Students will have a clear understanding of genetic regulation during development from embryogenesis to the adult.
- Students will connect with how developmental mechanisms are conserved across species and how evolution has shaped the developmental pathway.
- By understanding the fundamental biology of development, targets for intervention in various diseases can be identified, leading to new therapeutic strategies.

SYLLABUS OF DSC-4: Developmental Biology

MS ZOOLC-201

Unit 1. Overview of developmental biology **16 h**

Cell division, cell differentiation, signaling, patterning; Evolution of developmental patterns; Early embryonic development in invertebrates and vertebrates model organisms: Structure of the gametes; Cleavage and gastrulation; Axes and germ layers; Morphogenesis: cell adhesion, neural tube formation, cell migration.

Unit 2. Axis specification **8 h**

Role of maternal genes, patterning of early embryo by zygotic genes- gap genes, pair–rule genes, segment polarity genes, homeotic selector genes- bithorax and antennapedia complex.

Unit 4. Organogenesis and regeneration **14 h**

Development and patterning of vertebrate limb, homeobox genes in patterning, signaling in patterning of the limb; Insect imaginal discs–organizing center in patterning of the leg and wing, the homeotic selector genes for segmental identity; insect compound eye; Regeneration: Epimorphic regeneration of the Salamander limb; Morphallaxis regeneration in Hydra.

Unit 4. Medical implications **7 h**

Embryonic stem cells and their application; Gene expression and human disease – inborn errors; Teratogenesis, environmental impact on human development; Aging and senescence.

Practical **30 h**

1. Study of life cycle and developmental stages of *Drosophila melanogaster*.
2. Study of homeotic gene mutations and their effect on patterning.
3. Study of life cycle and developmental stages of zebrafish.
4. Study of life cycle and developmental stages of *C. elegans*.
5. Study of developmental stages of chick embryo.
6. Identification and study of larval and pupal wing, leg and eye antennal imaginal discs of *Drosophila*.
7. Mounting and observation of impact of cell death on wing patterning using *Drosophila* mutants.
8. Study of targeted gene expression of developmental genes using Gal4/UAS system in *Drosophila*.
9. Study and observation of ectopic expression of *eyeless* gene in *Drosophila*.

Essential/Recommended Readings

1. Developmental Biology: Scott F Gilbert [Latest edition].
2. Essentials of Developmental Biology: JMW Slack [Latest edition].
3. Principles of Development: Louis Wolpert [Latest edition].

Suggested Readings

1. Developmental Biology: Michael Barresi and Scott Gilbert [latest edition].
2. Key Experiments in Practical Developmental Biology: Jennifer Knight, Cambridge University Press
3. Latest research papers published in Developmental Biology, Developmental Cell, Genes and Development

Department of Zoology, University of Delhi

Discipline Specific Core-5 (DSC-5): Metabolism: Concepts and Regulation

MS ZOOLC-202

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 equip students with an in-depth understanding of how essential biomolecules are metabolized by biological systems and how these processes are regulated.
- To appreciate the interconnectedness of various metabolic processes and their adaptation during altered physiological states.
- To understand the principles of bioenergetics involved in metabolic processes.
- To explore the roles, mechanisms, and regulatory aspects of enzymes involved in metabolic processes.

Learning Outcomes

By studying this course, students will be able to:

- Understand carbohydrate, lipid, amino acid and nucleotide biosynthesis and degradation pathways, including their key enzymes, regulation and physiological relevance.
- Integrate and interpret the interplay between hormonal control and metabolismduring altered physiological states such as fasting and exercise.
- Apply the concept of metabolic reprogramming in specialized tissues and pathological conditions, and evaluate the use of enzymes and receptors as diagnostic and therapeutic targets.
- Demonstrate problem-solving in biochemical contexts by applying the acquired knowledge to interpret laboratory data, clinical case studies, and metabolic pathway maps.

SYLLABUS OF DSC-5: Metabolism: Concepts and Regulation

MS ZOOLC-202

Unit 1. Foundation of Metabolism **20 h**

Laws of thermodynamics and biological energy, ATP as energy currency, high-energy intermediates, biological oxidation-reduction reactions, NAD^+/FAD and their roles, mitochondrial function, electron transport and oxidative phosphorylation; Glycolysis and gluconeogenesis, TCA cycle, pentose phosphate pathway, glycogen metabolism; Fatty acid oxidation and synthesis, cholesterol metabolism, ketone body formation and utilization.

Unit 2. Enzymes and their regulation **8 h**

Enzymes: properties, classification and catalytic mechanisms; Mechanisms of chymotrypsin and lysozyme action; Enzyme kinetics: Michaelis-Menten kinetics, interpretation of K_m and V_{max}, turnover number; Inhibition of enzyme activity; Regulation of enzyme activity; Allostery.

Unit 3. Metabolism and Regulation of Proteins and Nucleotides **7 h**

Amino acid degradation. Biosynthesis of non-essential amino acids. Purine and pyrimidine degradation. Purine biosynthesis (de novo and salvage pathways), pyrimidine biosynthesis.

Unit 4. Integration of metabolism, hormonal control and metabolic reprogramming **10 h**

A broad outline of metabolic pathways and their linkage; Integration of metabolism and hormone action; Metabolism during fasting, starvation and exercise; Metabolic basis of specialized tissue function and diagnostics; Regulation of metabolism at molecular, cellular and organismic levels; Enzymes and receptors as drug targets.

Practical **30 h**

1. Preparation of a 'Good' buffer.
2. Preparation of molecular models of biomolecules using ball-and-stick.
3. Titration of an amino acid, an acidic dye and an organic acid to determine the pKa value.
4. Verification of Beer's Law.
5. Estimation of sugar(s), amino acid(s), vitamin(s), nucleotide/nucleic acid by appropriate biochemical methods.
6. Characterization of a purified protein/ enzyme for homogeneity by SDS-PAGE.
7. Determination of enzyme activity.
8. Kinetic characterization of enzyme(s).
9. Enzyme inhibition study.
10. Determination of activation energy of an enzyme-mediated reaction.
11. In gel staining of an enzyme activity (Zymogram).

Essential/Recommended Readings

1. J. M. Berg, J. L. Tymoczko, G. J. Gatto, Jr., LubertStryer (2015) Biochemistry, (Latest edition), W. H. Freeman and Company, New York, NY.
2. D.J. Voet, J.G. Voet, C.W. Pratt, (2016) Principles of Biochemistry, (Latest edition), John Wiley & Sons, Inc.
3. Lehninger by D. Nelson, and M. Cox, (2017) Principles of Biochemistry, (Latest edition), M.W.H. Freeman and Company, New York.

Suggestive Readings

1. P. J. Kennelly, K. M. Botham, O. Mcguinness, V. W. Rodwell, P. A. Weil (2022) Harper's Illustrated Biochemistry, 32nd Edition, McGraw-Hill.
2. Latest research papers published in Biochemistry, Journal of Biological Chemistry, Trends in Biochemical Sciences

Department of Zoology, University of Delhi

Discipline Specific Core-6: MS ZOOLC-203

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	0	1	B.Sc.	Nil	Zoology

Course Objectives

- This course is centered on the foundational principles of the immune system's structure, function, and regulatory mechanisms.
- It provides students with a basic understanding of innate and adaptive immunity, the coordination of immune responses, and the regulation of immune functions.
- The course also explores how immune processes are linked to health and disease.
- In addition, students will receive hands-on training in basic immunological techniques.
- By the end of the course, students will have a solid grasp of these foundational principles, preparing them for further academic or professional pursuits in the life sciences.

Learning Outcomes

The students opting for this course will

- Have a clear understanding of the basics of immunology.
- Be able to identify and describe the major components of innate and adaptive immunity.
- Describe key immunological concepts of antigen recognition by innate and adaptive immune cells.
- Explain the basics of MHC and antigen presentation.
- Understand mechanisms leading to the effector mechanisms of humoral and cellular immune responses.
- Describe the development, activation and regulation of lymphocytes and their functions.
- Perform basic immunological experiments important for future research and higher studies in the field.

SYLLABUS OF DSC-6: Immunology

MS ZOOLC-203

Unit1. Cells and tissues of the immune system **10 h**

Briefoverview of the immune system; Concepts of innate and acquired immune responses and their crosstalk; Active and passive immunity, natural, artificial and herd immunity; Primary and secondary immune responses; Lymphatic system and lymphoid tissue: Anatomy and functional significance of

thymus, bone marrow, spleen, lymph node, gut-associated lymphoid tissue, mucosa-associated lymphoid tissue (GALT/MALT).

Unit 2. Innate immunity and effector mechanisms **10 h**

Innate immune receptors andpatternrecognition; Effector functions of innatememory; Inflammation; Innate regulation: complement system, cytokines, NK and NKT cells.

Unit 3. Adaptive immunity **20h**

Antigen presentation**:** Antigen, antigenicity, superantigen; Antigen processing cells; Structure of major histocompatibility complex (MHC), antigen processing and presentation; Basic structure of antibody, antigen-antibody interactions, antibody diversity; Structure of T-cell receptors (TCRs), CD3 and accessory molecules of T-cells, T-cell co-receptors, antigen recognition by T-cells, adhesion molecules and their role in T-cell functioning; Effector mechanisms of humoral and cell mediated immunity.

Unit 4. Immunity in health and disease **5 h**

Hypersensitivity, autoimmunity, immunodeficiency diseases, immunity to microbes, tumour-immunology, vaccines.

Practical **30 h**

1. Identificationofprimaryandsecondarylymphoid organs.
2. Isolationoflymphocytesandviabilitycount.
3. Differential cell staining of blood cells.
4. Isolationofmacrophages.
5. Study of phagocytosis and phagocytic index.
6. Demonstration of immunization protocols to raise antibodies.
7. Study of antigen-antibody interaction using immuno-diffusion.

Essential/Recommended Readings

1. Kuby Immunology: Published by W.H. Freeman and Company (Latest edition)
2. Roitt's Essential Immunology: Published by Wiley-Blackwell (Latest edition)
3. BIOS Instant Notes in Immunology: Published by Taylor and Francis (Latest edition)
4. Basic Immunology: Abul K Abbas & Andrew Litchman. Published by Saunders Publication. (Latest edition)
5. Immunology: Understanding the Immune System. Klaus D. Elgert. Wiley-Blackwell (Latest edition)

Suggestive Readings:

1. Cellular & Molecular Immunology: Abul K. Abbas, Andrew H. Lichtman and Shiv Pillai. Published by Saunders Publication
2. Janeway's Immunobiology: Published by Garland Science/ Google Books.
3. Latest papers published in Nature, Cell, Current Opinions in Immunology, Trends in Immunology.

Department of Zoology, University of Delhi

Discipline Specific Elective DSE-5: MS ZOOLE-204

Cancer 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	1	0	B.Sc.	Nil	Zoology

Course Objectives:

- This course provides an in-depth exploration of cancer biology, focusing on the molecular mechanisms underlying cancer development, the role of immune system in tumor progression, and the impact of epigenetic modifications.
- Students will gain insights into the hallmarks of cancer, tumor microenvironment, metastasis, and therapeutic strategies, with an emphasis on current research and clinical applications.
- The programme provides research-led teaching in fundamental cancer biology, clinical oncology and the latest advances in modern therapeutics including immunotherapy and precision medicine.

Learning Outcomes:

- Upon successful completion of this course, students will gain foundational knowledge of cancer types, global epidemiology, and the multistage process of carcinogenesis. They will be able to understand the molecular mechanisms underlying the hallmarks of cancer, and distinguish the roles of oncogenes and tumor suppressor genes in tumor initiation and progression.
- The course equips students to interpret major signaling pathways involved in cancerand to evaluate their relevance in targeted therapy. Students will develop an understanding of cancer immunology, including immune surveillance, tumor antigens, immune checkpoint regulation, and modern immunotherapeutic approaches.
- Additionally, students will analyze the impact of epigenetic modifications in cancer development and treatment strategies. The course also covers the tumor microenvironment and mechanisms of metastasis and therapeutic resistance.
- Finally, through journal clubs and case studies, students will enhance their ability to critically assess current cancer research and apply this knowledge to translational and clinical contexts.

Syllabus of DSE-5: Cancer Biology

MS ZOOLE-204

Unit 1: Introduction to cancer biology **8 h**

Definitions, types of cancer; Epidemiology and global burden; Multistage model of carcinogenesis: Clonal evolution of tumors; Causes and risk factors of cancer, infection-associated cancers; Cancer and

the cell cycle, apoptosis; Hanahan & Weinberg framework: Self-sufficiency in growth signals, resisting cell death, sustained angiogenesis, immune evasion and metabolic reprogramming.

Unit 2: Oncogenes, tumor suppressor genes, molecular signaling and epigenetic control 15h

Proto-oncogenes vs oncogenes: Ras, Myc, HER2; Tumor suppressors: p53, RB, PTEN; Mechanisms of gene mutation, amplification, deletion, gene rearrangement; DNA repair pathways and genomic instability; RTK/PI3K/AKT/mTOR and MAPK pathways; Wnt/β-catenin and Hedgehog signaling; Notch signaling and cell fate decisions; Signaling crosstalk and pathway convergence; DNA methylation and demethylation; Histone modifications and chromatin remodeling; Role of epigenetic silencing in tumor suppressors; Non-coding RNAs: miRNAs, lncRNAs; Epigenetic therapies: DNMT and HDAC inhibitors.

Unit 3: Tumor microenvironment, metastasis, cancer immunology and immunomodulation 15 h

Components of the Tumor microenvironment **(**TME: CAFs, endothelial cells, immune cells, ECM, exosomes; Angiogenesis and hypoxia in tumor progression; Mechanisms of invasion and metastasis; Epithelial-mesenchymal transition (EMT); Immune surveillance and immunoediting; Tumor antigens and their presentation; Tumor-infiltrating immune cells; Role of cytokines and tumor-associated macrophages; Immune checkpoints: CTLA-4, PD-1/PD-L1; Current immunotherapies and resistance mechanisms; CAR-T cells and cancer vaccines.

Unit 4: Cancer therapeutics, stem cells and resistance 7 h

Chemotherapy and radiation: mechanisms, role of cancer stem cells; Targeted therapies and precision oncology; Resistance mechanisms: primary, acquired, adaptive; Emerging modalities: RNA-based therapeutics and nanoparticle delivery.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics by Lauren Pecorino, (Latest edition), 2021
2. Cancer Biology by Raymond W. Ruddon, (Latest edition), 2007
3. The Biology of Cancer by Robert A. Weinberg, (Latest edition), 2023
4. Cancer Immunotherapy Principles and Practice by Lisa Butterfield, (Latest edition), 2021
5. Key review articles from Nature Reviews Cancer, Cell, Cancer Cell

Suggestive Readings

1. Latest research papers published in Nature Reviews Cancer, Trends in cancer, Seminars in Cancer, BBA reviews on cancer

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Discipline-Specific Elective-6 (DSE-6): MS ZOOLE-205

Neurobiology

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

- This course aims to provide a broad introduction to the nervous system, scientific concepts underlying the study of neural phenomena, and principles underlying cellular, molecular, developmental, sensory, motor, and cognitive neurobiology.

Learning Outcomes

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

- Conceptualize how different cell types in the brain are involved in the complex transmission of information essential for the regulation of physiological processes.
- Understand the cellular and molecular mechanisms involved in multifaceted functions regulated by the central nervous system.
- Develop a critical viewpoint and interpret observations from brain behavior and cognition experiments.
- Understand the consequences of the disruption of brain physiology on health in the modern world.

Syllabus of DSE-6: MS ZOOLE-205

Neurobiology

Unit 1. Organization of the nervous system and chemical transmission 7 h

Brain structure, Neurons and glia, Neuronal system: limbic and extrapyramidal, Transmission of nerve impulse, Types of synapses, Excitatory and inhibitory post-synaptic potential, Chemical transmission, neurotransmitters and neuropeptides; Blood-brain barrier.

Unit 2. Glial Cell Biology 8 h

Glial cells: Structure, types and function; Importance of astrocytes in glutamate metabolism and blood-brain barrier; Microglial phenotypes,role of oligodendrocyte and microglial cells in brain health; Glial–neuronal interplay in CNS.

Unit 3. Developmental Neuroscience 15 h

Neural Induction, Signaling molecules that pattern the anterior-posterior axis in vertebrates, Neuronal determination and differentiation, Neuronal death during development, Neurotrophic factors: Neurotrophins and their receptors, intracellular-signaling pathways for neuronal survival, axon growth,

pathfinding and nerve patterns; Directional guidance of nerve growth cones; Synapse formation and elimination; Refinement of synaptic connections; Rearrangement of developing neuronal connections; Denervation and regeneration of synaptic connections; Regeneration of central and peripheral axons in mammalian nervous system.

Unit 4. Cognitive neuroscience, brain aging and neurodegeneration **15 h**

Learning, memory, motivation, sleep, perception, attention, consciousness, control, logic, language, molecular mechanisms involved in behavioural and cognition, Applications and methods in behavioural neuroscience; Age-associated structural alterations, functional changes and neuroplasticity, Neurodegeneration: Stroke, Epilepsy, Alzheimer's disease, Huntington disease, Parkinson's disease.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Eric Kandel: Principles of Neural Science (Latest edition, McGraw-Hill)
2. Longstaff: Neuroscience (Latest edition, Viva Books)
3. Shepherd: Neurobiology (Latest edition, Oxford Univ Press)
4. Squire et al: Fundamental Neuroscience (Latest edition, Academic Press)

Suggestive Readings

1. Latest research papers published in Nature Neuroscience, Molecular Neurobiology, Glia

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Discipline Specific Elective-7 (DSE-7): MS ZOOLE-206

Biology of Parasitism

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

- This course provides a comprehensive overview of the biological foundation of parasitic lifestyles, with an emphasis on host responses and the strategies parasites use to evade host defense mechanisms.
- Students will have a unique opportunity to study various parasites that infect humans, plants, and animals, deepening their understanding of parasite biology.
- The curriculum specifically addresses host specificity and the evolutionary dynamics of host-pathogen interactions. Additionally, students will gain essential knowledge in the transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment, and control of parasites.
- This program is carefully designed to equip students with the practical knowledge and skills needed for successful career in parasitology, public health, and related fields.

Course Outcomes

The students who participate in this course will have:

- Idea of some important pathogens that impact health of humans, animals and plants in the country.
- Detailed knowledge of the evolutionary dialogue critical for establishing host-parasite relationship.
- Understanding of the different strategies employed by the parasites to successfully establish infection in a host.
- Idea of the different strategies host uses to contain parasitic infection.

Syllabus of DSE-7: Biology of Parasitism

MS ZOOLE-206

Unit 1. Host-parasite interaction **5 h**

Animal associations and evolution of host – parasite relationship, Immune response and self-defense mechanisms, immune evasion and biochemical adaptations of parasites; Zoonosis.

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Unit 2. Blood parasites **16 h**

Malaria: Life cycle and epidemiology, mode of infection, detection, immunity and immune evasion mechanisms: Coordinated switching for antigenic variation by malaria parasites, drug targets and mechanisms of drug resistance, malaria vaccines; Leishmaniasis: Life cycle and epidemiology, Sand fly biology in the life cycle of Leishmania, role for sand fly gut microbiota in Leishmania development and transmission, detection, protective and pathologic immune responses in leishmaniasis, immune evasion mechanisms, drug targets and mechanism of drug resistance, vaccine strategies; Filariasis: Life cycle and epidemiology, pathology, role of host immunity in protection and pathology, Wolbachia in disease prognosis, drug targets and mechanisms of drug resistance, vaccine strategies.

Unit 3. Gastro-intestinal and other parasites **14 h**

Amoebiasis: Lifecycle and epidemiology, pathology, virulence factors and their role in immunity and immune evasion mechanisms, trogocytosis and its role, drug targets and mechanisms of drug resistance, vaccine strategies; *Schistosoma*, Ancylostoma, Trichinella and Dracanculus : Life cycle and epidemiology, mode of infection, detection, immunity and immune evasion mechanisms, drug targets and mechanisms of drug resistance, vaccine strategies.

Unit 4. Beyond humans **10 h**

Parasites of veterinary importance; Parasitic insects, mites and ticks; parasites of insects and their significance; Nematode parasites of plants, morphology, biology, lifecycle and infection of crop plants by major plant parasitic nematodes, host parasite interactions.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential readings

1. Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA (Latest Edition)
2. Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwell, U. K. (Latest Edition)
3. Parasitology: A Conceptual Approach, Eric S. Loker, Bruce V. Hofkin (Latest Edition)

Suggestive readings

1. Latest research papers published in Cell Host & Microbes, Plos Neglected and Tropical Diseases, Int J of Parasitology, Trends in Parasitology, Virulence, Gut Pathogens

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Discipline Specific Elective-8 (DSE-8): MS ZOOLE-206

Pharmacognosy and Basics of Traditional Medicine

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 Objective

- The alternative medical system known as Ayurveda first emerged on the Indian subcontinent.
- The idea that conventional and traditional medical procedures might complement one another to improve patient care is becoming increasingly accepted.
- After completing this course, students will know how to combine the traditional knowledge of Ayurveda with the most recent scientific findings.

Learning Outcomes

- Students will learn about many forms of traditional and alternative medicine.
- Students will learn how to use sophisticated tools in the exploration of natural sources of therapeutic agents.
- Students will be able to understand how the raw natural ingredients are used in the production of herbal medications from the cultivation to the making of the final product.

Syllabus of DSE-8: Pharmacognosy and Basics of Traditional Medicine

MS ZOOLE-207

Unit 1. Modern approach to traditional medicines 8 h

Introduction to pharmacognosy; Bioactive compounds from plants, animals and minerals. Uses of natural bioactive compounds in traditional and modern medicines. Traditional systems of Medicine. Concept of AYUSH; Origin of Ayurveda and its Vedic basis; Principles of treatment in traditional medicinal system.

Unit 2. Bioprospecting and drug discovery 13 h

Systematic exploration of natural sources for the identification, extraction and characterization of bioactive compounds; Biological activities of phytocompounds. Good manufacturing practices (GMP) of herbal drugs. Databases of phytocompounds, pharmacopia.

Unit 3. Pharmacology of natural medicines 12 h

Solubility kinetics and pKa, pH profile, partition coefficient, crystal morphology, polymorphism, powder flow, surface characteristics, dissolution, solubilization techniques. Mechanism of drug action, dose-

response and time-plasma drug concentration curves, concept of drug safety and therapeutic index, drug forms; Routes of administration, pharmacokinetics and pharmacodynamics.

Unit 4. Nano phytomedicine and global regulations regarding natural drugs 12h

Herbal nano-formulations an effective way of drug delivery; Biomolecules and nanoparticle interactions, nanoparticles preparation and characterization. Preclinical studies and clinical trials of natural medicines; Concept of BioPiracy; Ethnomedicine in Indian context; Herbal pharmaceutical regulations in India, Europe; WHO approval, and herbal drug dossier preparation.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Herbal Medicine Biomolecular and Clinical Aspects (Latest edition) by Iris F. F. Benzie, SissiWachtel-Galor.
2. Traditional Medicine New Research (Latest edition) By Yoshiharu Motoo.
3. Traditional Herbal Medicine Research Methods Identification, Analysis, Bioassay, and Pharmaceutical and Clinical Studies (Latest edition) By Willow J.H. Liu.

Suggestive Readings

1. Herbal Medicine in India: Indigenous Knowledge, Practice, Innovation and Its Value (2019) By Saikat Sen, Raja Chakraborty.
2. Evidence-Based Validation of Herbal Medicine Translational Research on Botanicals (2022) By Pulok Mukherjee.
3. Ayurveda A Comprehensive Guide to Traditional Indian Medicine for the West (2008) By Frank John Ninivaggi.
4. Ayurvedic Medicine: The Principles of Traditional Practice (2013) By Sebastian Pole.
5. Natural Products and Nano-Formulations in Cancer Chemoprevention (2023) By Shiv Kumar Dubey
6. Latest research papers published in Natural Product reports, Phytomedicine, Phytotherapy research

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General Elective-2 (GE-2): MS ZOOLGE-208

Animal Models in Research

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 demonstrate how model organisms can be raised and bred in laboratories to study their development and behaviour in a controlled and accelerated manner.
- To learn what are model organisms and their characteristic features.
- To illustrate how model organisms can be used to illustrate complex biological mechanisms.
- To study genetic and physiological similarities of model organisms with human.
- To illustrate how research on model organisms has led to many ground breaking discoveries, including the development of vaccines and new therapies for human diseases.

Learning Outcomes

- By studying this course, students will be able to:
- Appreciate the relevance of using animals to study human diseases.
- Elaborate as to how such studies can result in better and deeper understanding of human diseases.
- Discuss examples of how animal models have helped in developing vaccines, drugs and other approaches to manage human diseases.
- Understand the limitations of animals for modeling many human diseases.

Syllabus of GE-2: Animal Models in Research

MS ZOOLGE-208

Unit 1. *Drosophila melanogaster* **12 h**

General introduction about model organisms; characteristic features of model organisms.*Drosophila* culture and maintenance; Basic concepts of Genetics and Developmental Biology using *Drosophila*, Application for research in Biology and Biomedical research, *Drosophila* as an advanced model for generating mutants, genetic modifications, targeted gene expression. Insect cell culture: Pesticide assay, insect bauculovirus system for producing recombinant proteins in insect cells

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Unit 2. *Caenorhabditiselegans* **11 h**

Breeding and maintenance introduction of *C.elegans*biology, Application in research, Experimental design using C.elegans to study biological process, Emerging model in Pharmacological Innovation, Aging and Senescence, Chemotaxis and Behavior, Fluorescence Microscopy and Imaging.

Unit 3. *Danio rerio* (Zebrafish) **11 h**

Origin and natural habitat, Zebrafish in research: history and rise as a model organism, Advantages over other vertebrate models, life cycle overview, Embryogenesis and organ development, setting up a zebrafish facility, tank systems and water quality parameters, breeding protocols, behavior analysis, disease models, developmental biology, genetics, cancer, neurodegeneration, infection, environmental toxicology and ecotoxicology studies, micro biome and host-pathogen interaction studies.

Unit 4. *Mus musculus* (Mouse) **11 h**

Establishment of mouse as a model organism; Availability of coat colour and behavior mutations for study. Development of the mouse; Breeding and maintenance of mice; Probing the immune, endocrine, nervous, cardiovascular, physiological systems with mouse model. Application in biological and biomedical research; Toxicology; Drug discovery.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Animal Models in Research – Principles and Practice, HarikrishnanVijayakumar Sreelatha, Satish Patel, PerumalNagarajan, Springer Nature
2. Laboratory Animal Medicine, James G. Fox, Lynn C. Anderson, Glen M. Otto, Kathleen R. Pritchett-Corning, Mark T. Whary, Elsevier (Third Edition)
3. *Drosophila* - A Practical Approach, D.B. Roberts, Oxford Science Publications, New York, USA (Second Edition)
4. Biology of *Drosophila*, M. Demerec, John Wiley & Sons, Inc., New York, USA (Facsimile Edition)
5. Fly Pushing – The Theory and Practice of *Drosophila* Genetics, Ralph J. Greenspan, Cold Spring Harbor Laboratory Press, New York, USA (Second Edition)
6. *Drosophila* Protocols, William Sullivan, Michael Ashburner, R. Scott Hawley, Cold Spring Harbor Laboratory Press, New York, USA
7. Zebrafish, Christiane Nusslein-Volhard and Ralf Dahm, Oxford University Press
8. Mouse models in human disease (DOI: 10.1007/978-1-4939-9086-3_1)

Suggestive Readings

1. Biology of *Drosophila*, M. Demerec, John Wiley & Sons, Inc., New York, USA (Facsimile Edition)
2. Nagy A, et al (2003): Manipulating the mouse embryo: A laboratory manual; CSHL Press]
3. Booklet_Mouse_Models
4. Latest research papers published in Journal of Experimental Biology, Laboratory Animal Research, Animal models and Experimental medicine

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Skill Based Course-2 (SBC-1): MSZOOLS-209

Specialized Laboratory Course in Zoology Part II

Course title and Code	Credits	Credit distribution of the course			Eligibility Criteria	Prerequisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
MSZOOLS-209	2	0	0	2	B.Sc.	Nil

1. Learning Objectives

- To gain practical expertise in handling cancer cell lines, including culturing, preservation, and revival, as well as designing and interpreting viability and drug sensitivity assays using aseptic laboratory techniques.
- Hands-on experience on techniques and methodologies essential for studying pathophysiology related to central nervous system at morphological, behavioural, cellular and molecular level.
- To develop the ability to identify and understand the morphology, life cycles, and host interactions of key parasites.
- To sensitize students towards the natural sources of medicines and idea of conventional and traditional medical procedures.
- Enabling students to develop skills in designing and conducting experiments, recording accurate observations, and analyzing data.
- To appreciate role of biology in various fields including disease, medicine, agriculture, biotechnology.

2. Learning Outcomes

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

- Students will be able to independently culture, maintain, and assess cancer cell lines.
- Assess brain function and structure by performing cognitive and memory tests and carry out biochemical and molecular investigations of brain tissue
- Accurately identify and characterize major parasites and their vectors using microscopy and morphological features.
- Deploy sophisticated tools in the exploration of natural sources of the therapeutic agents.

3. Main Course Structure

Module 1 **30h**

Section A: Cancer Biology

1. Culturing cancer cell lines and their propagation. Cryopreservation of cancer cells and their revival from the frozen stocks.

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2. Testing cancer cell cultures for mycoplasma contamination. Assessing cell viability and counting of cells using Trypan Blue dye exclusion test.
3. Assessing drug sensitivity of cancer cells using MTT assays and calculation of IC50.
4. Immunofluorescence to study cancer-related protein localization.

Section B: Neuroscience

5. Studies on spatial learning and memory in rat/mouse model by Morris-Water/ Radial-Arm Maze Tests, Y-maze.
6. External morphology of rat/mouse brain.
7. Spectrophotometric assay of acetylcholine esterase.
8. Development of mice/rat models of neurodegeneration.

Module 2 **30h**

Section A: Biology of parasitism

1. Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, helminths and arthropods.
2. Demonstration of in vitro culture of Plasmodium.
3. Studying the life cycle of insect parasitic nematode.
4. Studying the infection of tomato plant by root knot nematode.

Section B: Pharmacognosy and Basics of Traditional Medicine

5. Preparation of crude extracts of phytochemicals.
6. Preliminary screening of phytochemicals (Mayer's test, Dragendorff's test, Wagner's test, Hager's test, Murexide test and Thalleioquin Test).
7. Maceration, digestion and Soxhlet method of extraction.
8. TLC analysis of medicinal plant crude extract.

4. Teaching Methodology/Activities in the classroom: Following methods will be used:

- **Lab Demonstrations & Hands-on Experiments**: Engage students with practical demonstrations using previously recorded data and real laboratory techniques to reinforce theoretical concepts.
- **Data Analysis**: Teach analytical skills by working with real datasets, including interpretation and presentation of results.

5. Assessment Pattern for each Unit/practical. Component of Attendance in the Assessment of 1 credit theory course

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

6. Mapping with the next suggestive course

Students can enhance skills by opting for specialized programs in cancer biology. neurobiology, molecular parasitology, and phytochemistry.

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7. Prospective Job Roles after a particular course

This course leverage skill in cell culture, molecular and biochemical assays, animal handling, microscopy, plant and parasite studies, and phytochemical analysis, providing a strong foundation for laboratory-based and applied research careers in biomedical and life sciences
1. Clinical & Laboratory Roles: Clinical Research Assistant, Biomedical Technician, Laboratory Assistant, Molecular Diagnostics Technician
2. Public Health Sector: Vector control
3. Eligible for technical positions in the Aayush sector and also eligible for Aayush NET examination.

Employment Sectors:

- Research institutes
- Hospitals
- Biotech companies
- Pharmaceutical and Herbal medicine companies
- Public health sector
- Agricultural research centers
- Quality control labs

8. Essential Reading

1. Freshney, R. Ian. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. 8th Edition, Wiley-Blackwell, 2021.
2. Matt Carter and Jennifer Shieh, Guide to Research Techniques in Neuroscience
3. Garcia, L. S. (2020). Diagnostic Medical Parasitology. United States: Wiley.
4. Herbal Medicine in India: Indigenous Knowledge, Practice, Innovation and Its Value (2019) By Saikat Sen, Raja Chakraborty.

9. Suggestive Reading

1. Bairoch, Amos. “The Cellosaurus: A Cell-Line Knowledge Resource.” Nucleic Acids Research, Vol. 46, No. D1, 2018, pp. D825–D830.
2. Eric Kandel: Principles of Neural Science (2000, McGraw-Hill)
3. Paniker, C. K. J. (2017). Paniker's Textbook of Medical Parasitology. India: Jaypee Brothers Medical Publishers Pvt. Limited.
4. Traditional Medicine New Research (Latest edition) By Yoshiharu Motoo.

Prof. Rita Singh
(*Head of the Department*)