UNIVERSITY OF DELHI

CNC-II/093/1(28)/2023-24/281

Dated: 06.10.2023

N O T I F I C A T I O N

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-6/-) dated 09.06.2023 and 27-1-1/ dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV, V and VI of the following departments under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23 :

(i) Botany

(ii) Geology

(iii) Zoology

(iv) Zoology Component for BSc. Life Science

DEPARTMENT OF ZOOLOGY
SEMESTER - V
Category I

(B.Sc. Honours in Zoology in three years)

DISCIPLINE SPECIFIC CORE COURSE -13 –:
Principles of Immunology
Zoo-DSC-13

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Principles of Immunology Zoo-DSC-13	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**

Learning Objectives

The learning objectives of this course are as follows:

- to impart an in-depth knowledge on how our immune system fights with infection and foreign substances that can harm our body
- to understand and design new therapeutics against a wide range of diseases and infections.
- to assist in comprehending the quick response to pandemics in the form of vaccines
- to apprise the students on the development of therapies targeting different components of the immune system that can alter the progression of human inflammatory diseases and cancers.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the concepts of innate and acquired immunity.
- acquire knowledge of the immunogenicity of biomolecules
- comprehend and analyze the different cellular and humoral components of the immune system
- appreciate the contribution of various components of immune system in health and disease including basis of vaccination, autoimmunity, immunodeficiency and hypersensitivity

SYLLABUS OF DSC-13

UNIT 1: Overview of the Immune System **6 hrs**

Early theories (Selective and Instructional) and Clonal Selection theory; Innate immunity: components and defensive barriers of innate immunity. Adaptive immune system: Components and attributes of acquired immunity, humoral and cell mediated immunity, active and passive immunity, primary and secondary immune response,

UNIT 2: Antigens and Immunoglobulins **10 hrs**

Antigens and immunogens; antigenicity and immunogenicity; factors affecting immunogenicity; antigenic determinants and its properties (B- and T-cell epitopes); Haptens and Adjuvants.

Structure and functions of different classes of antibodies; antigenic determinants on immunoglobulin; Production and applications of monoclonal antibodies.

UNIT 3: MHC and Antigen Presentation **4 hrs**

Structure and functions of MHC (MHC-I & MHC-II); endogenous and exogenous pathways of antigen processing and presentation.

UNIT 4: Complement System and Cytokines **3 hrs**

Pathways of complement activation and biological consequences of complement activation; properties and functions of cytokines

UNIT 5: Immune System in Health and Diseases **7 hrs**

Vaccines and their types; Gell and Coombs classification of hypersensitivity; autoimmunity and immunodeficiency with suitable examples.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of lymphoid cells and organs in rat/mouse*.
2. Histological study of spleen, thymus and lymph nodes through slides/photomicrographs.
3. To study various types of white blood cells using Leishman's/Giemsa/Crystal violet stained blood smear.
4. To understand the antigen and antibody interactions by

i) Ouchterlony's double immunodiffusion method.

ii) ABO Blood group antigen determination by heamagglutination test.

iii) Demonstration of ELISA.

iv) Demonstration of Immunoelectrophoresis.

v) FACS

vi) RIA

vii) Elispot

5. Cell counting and viability test (trypan blue dye exclusion test) from splenocytes* from rat/mouse/any other species.
6. Project on any topic/ Project report on visit to any research institute/laboratory to study the immunological techniques.

*depending on availability of animals or sample.

Essential/recommended readings

Punt, J., Stranford, S., Jones, P., Owen, J.A. (2018) Kuby Immunology, VIII Edition, WH Freeman and Company
Abul Abbas, Andrew Lichtman, Shiv Pillai (2017) Cellular and Molecular Immunology; Elsevier
Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006) Immunology, VI; Edition, W.H. Freeman and Company
David, M., Jonathan, B., David, R. B. and Ivan, R. (2006) Immunology, VII Edition, Mosby, Elsevier Publication.

Suggestive readings

1. Singh, I. K. and Sharma, P. [Eds.] (2022) An Interplay of Cellular and Molecular Components of Immunology. Taylor & Francis group, CRC Press.
2. Kaur, H., Toteja, R., and Makhija, S. (2021) Textbook of Immunology, I.K International Publishing House and Wiley India Ltd
3. Singh, I. K. and Sharma, P. [Eds.] (2022) Essentials of Immunology, Laboratory Manual; Prestige Publishers.
4. Kenneth Murphy, Casey Weaver (2016) Janeway's Immunobiology; 9th Edition, Garland Science

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE -14 –:
Cell and Molecular Biology
Zoo-DSC-14

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Cell and Molecular Biology Zoo-DSC-14	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	Basic knowledge of cell biology

Learning Objectives

The learning objectives of this course are as follows:

- to provide an understanding of structure-function relationships of nucleic acids and protein and the regulatory processes.
- to demonstrate practical knowledge of raising, handling, maintenance and special features such as antibiotic resistance of a simple prokaryotic model organism, *Escherichia coli*.
- to empower the students with a broad range of research and development related to cell signalling, cell culture and cell lines.
- to elucidate the molecular machinery and mechanism of information transfer processes- transcription and translation-in prokaryotes and eukaryotes;

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the diverse cellular processes and cellular interactions.
- have an in-depth knowledge of the defects in cellular functioning and the molecular mechanisms that can lead to various diseases.
- appreciate the importance of homeostasis of the body and the adversities of disturbing it.
- acquire the basic information of cell signalling pathways and to elucidate its roles in gene expression and its regulation in eukaryotes.
- interpret the differences between cellular deaths; stem cells and their applications in therapeutic cloning and regenerative medicine.
- explain post-transcriptional modification mechanisms for the processing of eukaryotic mRNA.
- impart experimental skills used in clinical and research laboratories giving the students an extra edge for taking up higher studies.

Syllabus of DSC-14

UNIT- 1: Cell Signalling **3 hrs**

Introduction to cell signalling pathways GPCR, cAMP, PKA, CREB, target gene and a nuclear receptor pathway.

UNIT-2: Cell Death and Cell Renewal **4 hrs**

Apoptosis vs. necrosis; intrinsic and extrinsic pathways of programmed cell death; stem cells and maintenance of adult tissues; embryonic and induced pluripotent stem cells.

UNIT-3: DNA and its Replication **7 hrs**

DNA replication in prokaryotes and eukaryotes-replication machinery and mechanisms, semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear double stranded DNA, Replication of telomeres.

UNIT 4: Transcription **5 hrs**

Machinery and mechanism of transcription in prokaryotes and eukaryotes-RNA polymerases, Transcription unit, Transcription factors, Synthesis of rRNA.

UNIT 5: Translation **5 hrs**

Genetic code, Process of protein synthesis in prokaryotes: fidelity of protein synthesis, aminoacyl-tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Difference between prokaryotic and eukaryotic translation.

UNIT 6: Post Transcriptional Modifications **2 hrs**

Split genes: concept of introns and exons, splicing mechanism, alternative splicing, and RNA editing.

UNIT 7: Gene Regulation **4 hrs**

Transcription regulation in prokaryotes: Lac operon; Overview of transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Requirement of a Tissue culture laboratory, its equipment and its layout. Concept of cell culture and cell lines; Media preparation for mammalian tissue culture.
2. Preparation of permanent slides of mitosis/meiosis*.
3. Study of Polytene chromosomes from *Chironomous*/*Drosophila* larva.
4. Inoculation and culture of *E. coli* in liquid culture medium (LB).
5. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
6. Estimation of the growth kinetics of *E. coli* from the data provided.
7. Quantitative estimation of salmon sperm/calf thymus DNA using colorimeter.

(Diphenylamine reagent) or spectrophotometer (A_{260} measurement).

8. Study and interpretation of electron micrographs/photographs showing: DNA replication, Transcription, and Split genes.
9. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

*Subject to UGC guidelines

Essential/recommended readings

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
2. R. Ian Freshney (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; Wiley-Blackwell.
3. Lodish et. al., (2007), Molecular Cell Biology, W.H. Freeman and Company, New York, USA
4. Alberts et. al., (2008), Molecular Biology of the Cell Garland Science, Taylor & Francis Group, New York, USA.
5. Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

Suggestive readings

1. Watson, J. D. Baker T.A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2008) Molecular Biology of the Gene.VI edition. Cold Spring Harbour Lab. Press, Pearson Pub.
2. Lewin B. (2008). Gene XI. Jones and Bartlett.
3. Gupta, R., Makhija, S. and Toteja, R. (2018). Cell Biology Practical Manual, Prestige Publishers, New Delhi-110003.
4. Sharma, V. K. (1991). Techniques in Microscopy and Cell Biology, Tata McGraw Hill Publishing Company Limited, New Delhi.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE 15–:
Fundamentals of Genetics
Zoo-DSC-15

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Fundamentals of Genetics Zoo-DSC-15	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL

Learning Objectives

The learning objectives of this course are as follows:

- to be able to list some of the distinguishing features of prokaryotes versus eukaryotes.
- to provide an understanding of the basic patterns of inheritance.
- to explain how genotype is related to phenotype?
- to describe how a mutation can change the phenotype.

Learning Outcomes

By studying this course, students will be able to

- Enhance knowledge of the basic principles of inheritance.
- Develop analytical skills and critical thinking through pedigree analysis.
- Understand the mechanism of gene transfer and mapping in both prokaryotes and eukaryotes.
- Learn the mechanisms of mutations and harmful and beneficial effects of mutagens, which help evolve new species over time.
- Be able to grasp basic concepts of human chromosomal disorders.

SYLLABUS OF DSC-15

UNIT- 1: Mendelian Genetics and its Extensions **7 hrs**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, penetrance and expressivity, Epistasis, Phenocopy, Pleiotropy, Polygenic Inheritance, Sex-linked, Sex-influenced, and Sex-limited characters inheritance.

UNIT- 2: Linkage, Crossing Over and Chromosome Mapping **6 hrs**

Linkage and crossing over, Cytological basis of crossing over, Recombination frequency

as ameasure of linkage intensity, two-factor and three-factor crosses, Linkage map, Coefficient of Coincidence and Interference, Gene mapping by Somatic cell hybridization.

UNIT- 3: Mutations **8 hrs**

Types of gene mutations, Detection of mutations in *Drosophila*: CLB method, Mutagens: Physical and chemical, molecular basis of spontaneous and induced mutations, Chromosomal aberrations: Structural Variations in chromosomes, Aneuploidy & Polyploidy.

UNIT- 4: sex Determination **3 hrs**

Basis of sex determination: Genetic and environmental; Sex determination in *Drosophila* and human; Mechanism of dosage compensation.

UNIT- 5: Extra-chromosomal Inheritance **3 hrs**

Comparison of nuclear and extranuclear inheritance; Organelle inheritance: Antibiotic resistance in *Chlamydomonas*, Infective heredity in *Paramecium*. Maternal effects: Shell coiling in *Limnaea*, pigmentations in *Ephestia.*

UNIT- 6: Transposable Genetic Elements **3 hrs**

Transposons in bacteria, Ty elements in yeast, Ac-Ds elements in maize, P elements in *Drosophila*, Transposons in humans, Significance of Transposons.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Simulation exercises using beads or seeds to study the gene interactions: 9:3:4; 12:3:1; 9:7; 9:3:3:1 (comb shapes in roosters) and verification of ratios by usingChi-square analysis.
2. Pedigree analysis of Autosomal Dominant trait, Autosomal recessive trait, X-linked Dominant traits, X-linked recessive traits, Y-linked traits and mitochondrial traits.
3. Use of probability in solving problems of genetics (Sum rule, Multiplication rule & Binomial expansion).
4. Gene mapping (order and distance) using data from interrupted mating experiments in bacteria.
5. Linkage maps based on data (two - point and three - point crossing over) from *Drosophila*.
6. Human Karyotypes, Human chromosomal disorders & single gene disorders.
7. Project on Epigenetic, Eugenics, Euthenics and Euphenics.

*Subject to UGC guidelines

Essential/recommended readings

1. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons In.

2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cumming

3. Pierce, B. A. (2012). Genetics-A Conceptual Approach. IV Edition. W. H. Freeman and Company

Suggestive readings

1. Peter, J. Russell. (2009), iGenetics: A molecular approach. 3rd Edition. Benjamin Cumming

2. Anthony J.F. Griffiths, Susan R. Wessler, Richard C. Lewontin, Sean B. Carroll (2007). Introduction to Genetic Analysis. 9th Edition. W H Freeman.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-V

POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES

DISCIPLINE SPECIFIC ELECTIVES (DSE-9): Chronobiology
Zoo-DSE-9

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Chronobiology Zoo-DSE-9	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic knowledge of animal behavior**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to understand and appreciate the cyclic physiological phenomena.
- to acquaint the students to the concept of generation of internal time.
- to learn about the fascinating phenomena of seasonal migration and hibernation.
- to expose the students to clock dysfunctions
- to make the students aware of the various aspects of chronobiology and how it can be applied to therapeutics and medicine?
- to facilitate the students to learn about their very own rhythms of sleep and body temperature
- to familiarize the students to actograms and their interpretation and analysis.

Learning Outcomes

By studying this course, students will be able to

- better understand the concept and biological significance chronobiology.
- acquire knowledge about the various types of biological rhythms and their adaptive role.
- appreciate the importance of circadian rhythms in human mental and physical health.
- better understand physiological and molecular mechanisms controlling circadian rhythms.
- know the genetic components comprising the biological clocks.
- gain knowledge about the importance of photoperiodism and its association with circannual rhythms.
- learn about the applications of chronobiology in medicine, pharmacology and

therapeutics.

SYLLABUS OF DSE-9

UNIT- 1: Introduction to Chronobiology **8 hrs**

Historical developments in chronobiology; Biological oscillation: the concept of average, amplitude, phase and period; Types of Rhythms – Ultradian rhythms, Circadian rhythms, Infradian rhythms; Lunar rhythm; Circannual rhythm; Adaptive significance of biological rhythms.

UNIT- 2: Circadian rhythms **8 hrs**

Characteristics of circadian rhythms, Free-running rhythm; Temperature compensation; Masking and synchronization; Zeitgebers- Photic and non-photic Zeitgebers; Effect of light, Intensity- Aschoff's rule.

UNIT- 3: Biological clock system **9 hrs**

Input, time generation and output components; Central and peripheral clocks; Suprachiasmatic nucleus; Molecular mechanisms underlying the generation of circadian time in Drosophila and Mammals.

UNIT- 4: Circannual rhythm and Photoperiodism **9 hrs**

Circannual rhythms; Photoperiodism and regulation of seasonal reproduction in vertebrates; Migration in birds; Hibernation in mammals.

UNIT- 5: Circadian clock, diseases and therapeutics **11 hrs**

Circadian clock and sleep-wake cycle; Jet Lag, Shift work ; Sleep and Chronotypes; Consequence of clock dysfunction- Sleep Disorders, Depression, Anxiety, Stress, Cancer; Obesity, Immune Disorders; Chronopharmacology, Chronomedicine and Chronotherapy.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Study of basic characteristics of biological rhythms from a given dataset.
2. Study and actogram construction of locomotor activity of suitable animal models.
3. Study of body temperature rhythm using periodically assembled data.
4. Study of the alertness rhythm using periodically assembled data.
5. Study of phase shift in circadian rhythm using given data.
6. Research plan presentation/ project on circadian (daily) rhythm functions, like eating, sleep or body temperature.
7. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Binkley, S. (2020). Biological clocks: Your owner's manual. CRC Press.
2. Vinod Kumar (2017): Biological Timekeeping: Clocks, Rhythms and Behaviour.
3. Wirz-Justice, A., Benedetti, F., & Terman, M. (2013). Chronotherapeutics for Affective Disorders: A Clinician's Manual for Light and Wake Therapy. Karger Medical andScientific Publishers

4. Koukkari, W. L., & Sothern, R. B. (2007). Introducing biological rhythms: A primer on the temporal organization of life, with implications for health, society, reproduction, and the natural environment. Springer Science & Business Media.

Suggestive readings

1. Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Timekeeping.Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
2. Palmer, J. D. (2002). The living clock: The orchestrator of biological rhythms. OxfordUniversity Press.
3. Vinod Kumar (2002) Biological Rhythms. Narosa Publishing House, Delhi/ Springer-Verlag, Germany.
4. Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York, USA
5. Weiner, J. (2000). Time, love, memory: a great biologist and his quest for the origins ofbehavior. Vintage.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-10):
Integrative Systems Biology and Bioinformatics

Credit distribution, Eligibility and Pre-requisites of the Course

Course Title & Code	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Integrative Systems Biology and Bioinformatics Zoo-DSE- 10	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic knowledge of computer and biology**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to give an overview of the key principles of Systems Biology and Bioinformatics.
- to introduce students to a variety of *in silico* solution for biological problems and systems data by analysing biological databases, gene sequence alignments, gene annotation, structure predictions, and drug development, among other areas.
- to encourage undergraduate students to pursue higher education in this field as Bioinformatics has been identified as a critical area of study and development

Learning Outcomes

By studying this course, students will be able to:

- know more about the basic of systems biology and bioinformatics
- better understand about the availability of experimental data through biological databases, usage of small molecules, nucleic acids, protein sequences, in a variety of biological sciences domains
- gain more knowledge about the gene sequence annotation, protein structure prediction and gene enrichment prediction
- acquire skills to perform and understand pair-wise and multiple sequence alignment
- better understand a variety of computational tools and approaches, as well as their use in *in silico* drug discovery, structural bioinformatics, and functional genomics etc.

SYLLABUS OF DSE- 10

UNIT- 1: Introduction to Systems Biology and Bioinformatics **5 hrs**

Introduction to Systems Biology, Bioinformatics, Genomics, Proteomics, Transcriptomics, Metabolomics, Scope and their applications.

UNIT- 2: Systems Biology **10 hrs**

Computational models, modelling and their basic notions, networks (feed forwardgene circuit,transcription regulatory networks and protein-protein interaction networks)

UNIT- 3: Biological Databases **8 hrs**

Introduction to biological databases; Primary, Secondary and Composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, Reactome, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD)

UNIT- 4: Sequence Alignment and Phylogeny **10 hrs**

Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); HMM model, Local and global alignment, pair wise and multiple sequence alignments, Molecular Phylogeny.

UNIT- 5: Structural Biology and Drug Discovery **12 hrs**

Protein secondary structure prediction (Chou-Fasman & GOR methods), Protein tertiary structure prediction and its validation (Homology modelling, Threading and *Ab-initio* methods); Lipinski rule, Molecular docking (rigid and flexible docking), ADMET properties, Molecular Dynamics, Drug-DNA interactions.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Retrieval of DNA, RNA, protein sequences and structures from the biological databases and to create various datasets.
2. Perform pairwise and multiple sequence alignments from the generated datasets in Experiment 1, using online/offline tool.
3. Retrieval and analysis of any one disease network from KEGG pathway database.
4. Gene functional enrichment analysis using DAVID tool.
5. Protein structure prediction through homology modelling using Swiss Modeller.
6. Molecular docking (Protein-ligand) using AutodockVina/ SwissDock/ PatchDock/ZDock (anyone).
7. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Pevsner, J. (2015) Bioinformatics and Functional Genomics, 3rd edition, Wiley and Blackwell.
2. Xiong, J. (2012) Essential Bioinformatics, Cambridge University Press.
3. Claverie, JM and Notredame, C. (2006) Bioinformatics for Dummies 2nd edition, Wiley Publishing Inc.
4. Klipp, E., Liebermeister, W., Wierling, C. and Kowald, (2016) A. System Biology 2nd edition, Wiley-VCH.

Suggestive readings

1. Alon, U. (2019) An Introduction to Systems Biology 2nd edition, CRC, Taylor & Francis.
2. Jenny Gu, J. and Bourne, P.E.(2011) Structural Bioinformatics 2nd edition, Wiley Blackwell.
3. Harren Jhoti, H. & Leach, A. (2007) Structure-based Drug Discovery, Springer.
4. Kitano, H. (2001) Foundations of Systems Biology, MIT press Cambridge.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-11): Basics of Neuroscience

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Dept offering the course
		Lecture	Tutorial	Practical			
Basics of Neuroscience Zoo-DSE- 11	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Concept of functioning of nervous system**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to understand the structure and function of the nervous system at the molecular, cellular, and systems levels.
- to provide an in-depth understanding of neuronal excitability, signal generation and propagation, synaptic transmission, post-synaptic mechanisms of signal integration, and neural plasticity.
- to gain an insight into how membrane excitability elicits functional effects in individual neurons and neuronal networks and how different parts of the brain control various behavioural patterns by releasing neurohormones/neuropeptides.
- to have a thorough knowledge of neuroimaging techniques and a comprehensive understanding of the kinds of information each technique provides about the brain.
- to gain knowledge about the neural mechanism and pathogenesis of common neurodegenerative disorders such as Alzheimer's, Parkinson's disease etc.

Learning Outcomes

By studying this course, students will be able to:

- understand the fundamentals of neuroscience, key concepts, and the relationship between the nervous system and behaviour/cognition.
- comprehend the neural basis of sleep, emotions, learning and memory and related aspects of cognition.
- have a detailed understanding of how different neuroimaging techniques are used to assess brain function and explore questions in clinical and behavioural neuroscience.
- explore potential developments to current research, design, execute and communicate a substantive research project in the field of neuroscience or its application.

SYLLABUS OF DSE- 11

UNIT- 1 Introduction to Nervous System **6 hrs**

Origins of Neuroscience; Neuron doctrine; Classification of the nervous system.

UNIT- 2 Structure of the Brain **5 hrs**

Gross anatomy of the human brain, Meninges, ventricular System, Blood-brain Barrier, Cranial nerves.

UNIT-3 Cellular and Molecular Neurobiology **10 hrs**

Classification of neurons; Structure of prototypical neuron; Electrophysiology of membrane potentials-resting and action potentials, generation, and propagation; Ion Channels and Membrane Ion Currents; Types of Synapses, synaptic transmission and integration; Post synaptic potentials - EPSPs and IPSPs; tripartite synapse.

UNIT- 4 Neurotransmitters **4 hrs**

Types of neurotransmitters; transmitter-gated channels; neurotransmitter receptors Ionotropic and metabotropic receptors; G-protein coupled receptors and effectors.

UNIT- 5 Cognitive and Behavioural Neuroscience **10 hrs**

Neurobiology of visual perception; Molecular basis of learning and memory: Classification ofmemory, amnesia, case of H.M. (Henry Malaison); Synaptic plasticity, Long-term potentiation (LTP), Long-term depression (LTD); Memory consolidation.

UNIT-6 Neurophysiology of Sleep **4 hrs**

Neurophysiology of sleep and wakefulness, electroencephalogram rhythms (EEG).

UNIT- 7 Neuroimaging and Neuropathology **6 hrs**

Computed Tomography Scan (CT), Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET); Neurological disorders (in brief)- Epilepsy, Schizophrenia; Aetiology and Molecular pathogenesis - Parkinson's, Alzheimer's.

Practical **(30 hrs)**
(Laboratory periods: 15 classes of 2 hours each)

1. Study of brain coordinates using stereotaxis instrument (video demonstration).
2. Study of *Drosophila* nervous system using GFP reporter system.
3. Study of anatomy of mammalian brain (from slaughter house or) using brain models (Medical anatomical teaching models, graphics, videos etc., can be used).
4. Histological study of neurons and myelin sheath (Nissl and Luxol Fast Blue staining).
5. Study of novelty, anxiety, and spatial learning in mice.
6. Histological study of the cerebellum and spinal cord by H&E stain and cerebral cortex by Nissl stain.

7. Study of neurodegenerative diseases (Parkinson's and Alzheimer's) with the help of brainscan images or brain tissue images.

Essential/recommended readings

1. Purves, D. et al., (2017) Neuroscience, VI Edition. Oxford University Press.
2. Bear, M. F., Connors, B. W. and Paradiso, M. A. (2016). Neuroscience: Exploring the Brain. IV Edition. Philadelphia: Wolters Kluwer.
3. Squire, L., Berg, D., Bloom, F. E., du-Lac, S., Ghosh, A., Spitzer, N. C. (2012) Fundamental Neuroscience, IV Edition, Academic Press Publications.
4. Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000) Principles of Neural Science. IVEdition, McGraw-Hill Companies.

Suggestive readings

1. Carter, R. (2014). The Human Brain Book. D. K. Publishers.
2. Stephan M. Stahl (2000) Essential Psychopharmacology- Neuroscientific Basis and Practical Applications. II Edition. Cambridge University Press.
3. Ramachandran, V. S. and Blakeslee, S. (1998). Phantoms in the Brain: Probing the Mysteries of the Human Mind. William Morrow, New York.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-12): Biology of Insecta
Zoo-DSE-12

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Biology of Insecta Zoo-DSE-12	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint the students about biology of class Insecta.
- to acquire knowledge of the morphology and physiology of Insects.
- to enable the students to see, appreciate and understand the diversity of insects.

Learning Outcomes

By studying this course, students will be able to:

- better appreciate the diversity of insects.
- better understand the physiology of Insects which has made them the most successful animalsin terms of numbers and variety of species.
- get acquainted with the highly organized social life of insects.
- to make the students aware about the possible scope of the subject which includes research and applied aspects including entrepreneurial skill.

SYLLABUS OF DSE- 12

UNIT-1 Introduction **4 hrs**

General features of Insects and their diversity; Classification of insects up to orders.

UNIT- 2: General Morphology of Insects **12 hrs**

Head: Eyes, Types of antennae, Mouth parts w.r.t. feeding habits; Thorax: wings- Typical structure of insect wing and its modifications, Types of Legs; Abdomen: Typical structure.

UNIT- 3: Physiology of Insects **18 hrs**

General aspects of the Integumentary (structure of integument and process of moulting), digestive, excretory, circulatory, respiratory, reproductive, and nervous system (using cockroach as the type representative); Metamorphosis: Types & hormonal control.

UNIT- 4: Insect behaviour **6 hrs**

Insect-Plant Interactions: Host-plant selection by phytophagous insects.

UNIT- 5: Insects as plant pests **5 hrs**

Bionomics and control of any two phytophagous insect pests of fruits, vegetables, cash crops and stored grains.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Methodology of collection, preservation and taxonomic identification of insects (classification up to order with the help of taxonomic keys).
2. Study of different kinds of antennae, legs and mouth parts of insects with the help of slides/specimens/ photographs
3. Study of morphological features of insects using pictures/slides/museum specimen (cockroach): head, sclerites, antennae, mouthparts, wing venation, and legs.
4. Preparation of temporary/permanent mount of any stored grain pest and its life stages.
5. Study of biology of any insect pest of agricultural crops (Fruit/vegetable).
6. Field study of insects and submission of a project report showcasing insect diversity.

Essential/recommended readings

1. Chapman, R. F. (1998) The Insects: Structure and Function. Cambridge University Press, UK.
2. Richards, O. W., Davies, R. G. (1977) Imms' General Text Book of Entomology. Vol I & Vol II; Chapman & Hall, UK.

Suggestive readings

1. Snodgrass, R. E. Principles of Insect Morphology. Cornell Univ. Press, USA.
2. Borror, D. J., Triplehorn, C. A., and Johnson, N. F. Introduction to the Study of Insects. M Saunders College Publication, USA.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-13):
Reproductive Biology and Assisted Reproductive Technologies (ART)
Zoo-DSE-13

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Reproductive Biology and Assisted Reproductive Technology (ART) Zoo-DSE-13	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint the students about the various aspects of reproduction in humans.
- to acquire in-depth knowledge of male and female reproductive systems as well as factors that are important in maintaining reproductive health.
- to enable the students to see, appreciate and understand the new technologies in assisted reproduction as well as contraceptive methods.
- to familiarize the students about the social and public health issues related to family planning.
- to make the students aware of the possible scope of the subject which includes research and applied aspects including entrepreneurial skills.

Learning Outcomes

By studying this course, students will be able to:

- get an in-depth understanding of morphology, anatomy, and histology of male and female reproductive organs.
- know different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition, and lactation.
- compare estrous and menstrual cycles and their hormonal regulation.
- comprehend the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.
- know about the diagnosis and management of infertility, including the latest methods, technologies, and infrastructure in assisted reproduction.
- better understand the modern methods of contraception and their use in family planning strategies.
- translate their understanding into the development of products like non-hormonal contraceptives; contribute to drug discovery programs as well as neonatal and

maternal health programmes and work with family planning teams to understand the needs and preferences of individuals belonging to lower socioeconomic groups.

SYLLABUS OF DSE-13

UNIT-1: Reproductive Endocrinology **8 hrs**

Hypothalamo–hypophyseal–gonadal axis; Regulation of gonadotropins and gonadal steroids secretion in male and female; Steroidogenesis; Mechanism of action of hormones related to reproduction.

UNIT- 2: Male Reproductive System **9 hrs**

Anatomy of the male reproductive system: Testis, epididymis, vas deferens, prostate gland, seminal vesicle; Spermatogenesis and its regulation; Sperm transport and maturation in the male genital tract.

UNIT- 3: Female Reproductive System **12 hrs**

Anatomy of the female reproductive system: Ovary, fallopian tubes/oviducts, uterus, cervix, and vagina; Folliculogenesis; Oocyte maturation and ovulation; Menstrual cycle and its hormonal regulation. Lactation and its regulation.

UNIT- 4: Fertilization **8 hrs**

Fertilization; Implantation; Feto-placental unit; Hormonal regulation of gestation; Parturition and its hormonal regulation;

UNIT- 5 Reproduction **8 hrs**

Modern contraceptive methods; Infertility in males and females- causes and diagnosis
Assisted Reproductive Technologies (ART): sperm banks, IVF, frozen embryos, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST. Ethical issues in ART.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Examination of histological sections from photomicrographs/permanent slides of rat/human: testis, epididymis, and accessory glands of male reproductive systems.
2. Sections of the ovary, fallopian tube, uterus (proliferative and secretory stages), cervix, and vagina.
3. Study the estrous cycle by examination of the vaginal smear of rats (from live animals)
4. Study of ovariectomy and castration.
5. Study of sperm count and sperm motility in rats.
6. Study of modern contraceptive devices.
7. Submission of project report on the reproductive health of a small human community involving survey, data collection, statistical analysis

OR

Report on the visit to animal culture facility including details about setting up and maintenance of the animal house, breeding techniques, care of normal and experimental animals.

*All exercises requiring live animals should be performed with the help of photomicrographs/pictures/videos.

Essential/recommended readings

1. Johnson, M.H. and Everitt, B.J. (2018) Essential reproduction. IV Edition, London, Blackwell Science.
2. Jones, R.E. and Lopez, K.H. (2014) Human Reproductive Biology. IV Edition, Elsevier.
3. Franklyn F. Bolander (2012) Molecular Endocrinology. III Edition, USA, Academic Press.
4. De-Groot, L.J. and Jameson, J.L. (eds) (2001) Endocrinology. W.B. Saunders and Company.

Suggestive readings

1. Knobil, E. and Neil, JD (eds) (2014) The Physiology of Reproduction. IV Edition, Elsevier.
2. Robert Martin (2013) How We Do It: The Evolution and Future of Human Reproduction. Basic Books.
3. Austin, C.R. and Short R.V. (Eds) (2012) Reproduction in Mammals. Cambridge University Press.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

GENERIC ELECTIVES (GE-11): Animal Cell Biotechnology
Zoo-GE-11

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Animal Cell Biotechnology Zoo-GE-11	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to give the students a fundamental understanding of the field of biotechnology.
- to provide a tool kit in the form of a number of techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine.
- to make the students aware of the scope of biotechnology which encompasses almost every field of science like engineering, research, commercialization and academics.
- to empower the students to face research and industrial outlets by nurturing independent thinking, initiating scientific enquiry and developing their entrepreneurship skills.
- to equip the students with basic understanding of the tools and techniques of biotechnology which are a must for anyone interested in pursuing a career in biotechnology.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the basic principles and applications of biotechnology.
- appreciate the basic techniques used in genetic manipulation helping them continue with higher studies in this field.
- acquire knowledge of the basic principles, preparations and handling required for animal cell culture.
- have an in-depth understanding of the principles underlying the design of fermenter and fermentation process and its immense use in the industry.

- enable students to design small experiments for successful implementation of the ideas and develop solutions to solve problems related to biotechnology keeping in mind safety factor for environment and society.
- apply knowledge and skills gained in the course to develop new diagnostic kits and to innovate new technologies further in their career.
- enhance their understanding of the various aspects and applications of biotechnology as well as the importance of bio-safety and ethical issues related to it.

SYLLABUS OF GE-11

UNIT- 1: Introduction **2 hrs**

Concept and Scope of Biotechnology.

UNIT- 2: **Techniques in Gene Manipulation** **9 hrs**

Outline process of genetic engineering and recombinant DNA technology, Restriction endonucleases, DNA modifying enzymes, Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids (lambda & M13). Shuttle and Expression Vectors. Genomic and cDNA libraries. Transformation techniques: Electroporation and Calcium Chloride method.

UNIT- 3: Fermentation **9 hrs**

Different types of Fermentation: Submerged & Solid state; batch, Fed batch and Continuous; Stirred tank, Air Lift, Downstream Processing: Filtration, centrifugation, extraction, chromatography (Only Principles: Adsorption, Ion exchange, gel filtration, hydrophobic, affinity and size exclusion and lyophilization.

UNIT- 4: Transgenic Animal Technology **5 hrs**

Production of transgenic animals: Retroviral method, DNA microinjection method, Nuclear Transplantation: Dolly and Polly.

UNIT- 5: rDNA Application in Health **5 hrs**

Recombinant vaccines, gene therapy (*in-vivo and ex-vivo*). Production of recombinant Proteins: Monoclonal Antibodies, Insulin and growth hormones, Bio safety: Physical and Biological containment.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Packing and sterilization of glass and plastic wares for microbial culture.
2. Preparation and sterilization of culture media.
3. Preparation of genomic DNA from *E. coli*.
4. Calculation of transformation efficiency from the data provided.
5. Restriction digestion of lambda (λ) DNA using EcoR1 and Hind III.

6. Techniques:
   a. Western Blot
   b. Southern Hybridization
   c. DNA Finger printing
   d. Polymerase chain reaction,
   e. DNA Microarrays
   f. Polyacrylamide gel Electrophoresis
   g. DNA sequencing: Sanger method

Essential/recommended readings

1. Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology- Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
2. Brown, T.A. (1998). Gene Cloning and DNA Analysis: An Introduction. II Edition, Academic Press, California, USA.
3. R. Ian Freshney (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; Wiley-Blackwell.

Suggestive readings

1. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
2. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA-Genes and Genomes-A Short Course. III Edition, Freeman and Co., N.Y., USA.
3. Mathur, J.P. and Barnes, D. (1998) Methods in Cell Biology: Animal Cell Culture Methods. Academic Press.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-12): Introduction to Public Health and Epidemiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Introduction to Public Health and Epidemiology Zoo-GE-12	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint students with the basic concepts and importance of epidemiology and its contribution in the public health research.
- to acquire knowledge about the descriptive, analytic, and experimental aspects that can be applied for assessing the epidemiological studies of health status in the Indian population-based registers.
- to understand the relevance of statistics for the analysis of health-related data and its implications in the health sector
- To enable students to interpret results of data analysis for public health research, policy or practice.

Learning Outcomes

By studying this course, students will be able to

- better understand the fundamental components of epidemiology and data analysis.
- gain an understanding of the unique resources that Indian health registers represent for epidemiological research.
- comprehend various types of epidemiological studies, and understand their 'hierarchy' with respect to research.
- evaluate and interpret basic measures of occurrence and association and interpret the results
- appreciate and analytically assess the collection, analysis of data, and evaluate the relevant hypotheses.
- evaluate the strengths and limitations of epidemiologic reports
- apply epidemiological thinking to critically read and appraise articles in medical literature.

SYLLABUS OF GE-12

UNIT- 1: Epidemiology of Infectious Diseases **12 hrs**

Modes of infections with suitable examples. Overview of cause, extent, prevention, treatment and control of the diseases: Respiratory infections, Intestinal infections, Arthropod-borne infections, Zoonosis and Surface infections.

UNIT- 2: Understanding Epidemiological Data **8 hrs**

Understanding incidence, mortality (rates, ratios and proportions); Components of epidemiology: disease frequency, distribution and determinants of diseases. Epidemiological approach and measurements- vital statistics, health indicator parameters (morbidity, mortality and fertility rates); Analysis of data from National Cancer Registry Program (NCRP) and Covid-19 data.

UNIT- 3: Epidemiologic Methods and Survey **6 hrs**

Outlining the parameters for ethical issues in a study. Determining the target and control populations; Designing of questionnaires; Data collection: Strength of observation (descriptive and analytical) and experimental studies. Epidemiology study designs- case control and cohort studies (prospective and retrospective), procedures of sampling and matching, sources of bias.

UNIT- 4: Collection, Tabulation and Representation of Data **4 hrs**

Analysis of data from NCRP data and survey conducted by the students. Basic principles of "R" software for tabulation and graphical representations (bar diagrams, histograms, pie charts, box plot, etc.), measures of central tendency (mean, mode, median and partition values), dispersion (range, standard deviation, coefficient of variance and covariance) and skewness.

Practical **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Designing a questionnaire for survey of prevalence diabetes/ hypertension/ allergy/ respiratory disorders/covid 19.
2. To conduct a population survey for the year for the any one of the disease- diabetes/ hypertension/ allergy/ respiratory disorders/covid 19.
3. Design an epidemiology study: case control and cohort study (prospective and retrospective), including techniques of sampling and matching, sources of bias.
4. Perform correlation and regression studies on the data collected.
5. Analyze the probabilistic distribution studies.
6. Comparison of groups and ascertaining statistical significance of differences.
8. Research and presentation on current trends in infectious diseases.

Essential/recommended readings

1. Glantz, S. (2011) Primer of Biostatistics, 7th edition, McGraw-Hill Medical. ISBN-13: 978-0071781503.
2. Park, K.(2011) Park's Textbook of Preventive and Social Medicine, 21st edition, M/s Banarsi Das Bhanot Publishers.
3. Bonita, R., Beaglehole, R., TordKjellstrèom, (2006) Basic epidemiology, 2nd edition (2006), Contributor; World Health Organization, illustrated, Publisher: World Health Organization.
4. Pagano, M. and Gauvrean, K. (2000) Principles of Biostatistics, 2nd edition, Thompson learning.

Suggestive readings

1. Wayne W Daniel and Chad L. Cross (2013), Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition, Wiley. ISBN-13: 978-1118302798.
2. Jerrold H. Zar (2009) Biostatistical Analysis, 5th edition, Pearson. ISBN-13: 978-0131008465.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-13): Concept of Animal Behaviour
Zoo-GE-13

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Concept of Animal Behaviour Zoo-GE-13	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to familiarize the students with the scientific study of the behaviour of animals.
- to enable students to link behaviour patterns to the brain, genes, and hormones, as well as to the surrounding ecological and social environments.
- to acquire knowledge of aggression, the chase of the hunter and the flight of the hunted, the spinning of webs, the digging of burrows, and the building of nests or remaining motionless and concealed.
- to provide a good understanding of various concepts in animal behaviour.
- to motivate students to pursue a career in animal behaviour.

Learning Outcomes

By studying this course, students will be able to

- better understand the various types of animal behaviour and their importance.
- enhance their observation skills, analytical skills, scientific interpretation and documentation skills.
- enable students to evaluate the characteristic features of animal life including static postures, active movements, noises, smells, changes in colour and shape.
- realise, appreciate and develop passion to biodiversity and respect the nature and its surroundings.

SYLLABUS OF GE-13

UNIT- 1: Introduction to Animal Behaviour **4 hrs**

Origin and history of ethology, Pioneers of modern ethology: Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Four Questions for Ethology.

UNIT- 2: Patterns of Behaviour **7 hrs**

Innate behaviour, Instinct, Sign stimuli, Code breakers, Learning: associative learning and non-associative learning, Classical and operant conditioning, Habituation, Imprinting.

UNIT- 3: Communication **3 hrs**

Importance of communication; Role of Chemical, Tactile, Auditory, Visual stimuli in communication.

UNIT- 4: Social Behaviour **7 hrs**

Concept of Society, Social insects (Honeybee as example), Bee communication, Altruism & Reciprocal altruism, Inclusive fitness, Hamilton's rule.

UNIT- 5: Sexual Behaviour **9 hrs**

Sexual dimorphism, mate choice; Intra-sexual selection (male rivalry); Inter-sexual selection (female choice); Courtship behaviour, Parental care, sexual conflict in parental care, Infanticide.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. To study nests and nesting behaviour of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm.
4. To study the phototaxis behaviour in insect larvae.
5. Study of different tools, techniques and methods used in preparing ethogram.
6. To study courtship behaviour in insects and birds from short videos/movies.

Essential/recommended readings

1. Alcock, J. (2013) Animal Behaviour, Xth Edition, Sinauer Associates Inc., USA.
2. Manning, A. and Dawkins, M. S, (2012) An Introduction to Animal Behaviour, VIth Edition, Cambridge University Press, UK
3. McFarland, D. (1985) Animal Behaviour, Pitman Publishing Limited, London, UK

Suggestive readings

1. Rubenstein, D. (2022) Animal Behavior, XIIth Edition, Sinauer Associates, Oxford University Press, UK.
2. Gadagkar, R. (2021) Experiments in Animal Behaviour: Cutting-Edge Research at Trifling Cost, Indian Academy of Sciences.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.