Appendix-38
Resolution No. 14-1 (14-1-5)

INDEX
DEPARTMENT OF ZOOLOGY
Semester-IV

SEMESTER-IV
BSc (Hons.) Zoology

DISCIPLINE SPECIFIC CORE COURSE -10 – : Comparative Anatomy of Vertebrates Zoo-DSC-10

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		
Comparative Anatomy of Vertebrates Zoo-DSC-10	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	Basic knowledge of Vertebrates

Learning Objectives

The learning objectives of this course are as follows:

- to impart in-depth knowledge about the structural patterns and a comparative account of the different organ systems of vertebrates.
- to understand the account of the functional and comparative morphology provides a deepunderstanding of animal diversity and the adaptive changes the vertebrates have gone throughduring evolution from common ancestors
- to help students identify the body plan types of complex chordates and their systematic organization based on evolutionary relationships, structural and functional affinities.
- to apprise the students about the correlation of comparative development to evolutionary biology and phylogeny, and how it helps in classifying animals.
- to enable students to establish the evolutionary links based on fossil records.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the evolutionary significance of comparative anatomy.
- understand the importance of morphology and anatomy of organisms in relation to evolution.
- appreciate the comparative anatomy among vertebrates that provides evolutionary evidences.
- enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions, assignments, and projects.

SYLLABUS OF DSC-10

UNIT 1: Integumentary System **4 hrs**

Structure and derivatives of integument.

UNIT 2: Digestive System **4 hrs**

Alimentary canal and associated glands; Dentition.

UNIT 3: Circulatory System **4 hrs**

General plan of circulation; Evolution of heart and aortic arches.

UNIT 4: Respiratory System **4 hrs**

Skin, gills, lungs, accessory respiratory organs in fishes, air sacs.

UNIT 5: Skeletal System **5 hrs**

Outline of axial and appendicular skeleton; Concept of neurocranium, dermatocranium and splanchnocranium; Structure of a typical vertebra and its classification based on centrum; Jaw suspensorium; General plan of girdles and limbs.

UNIT 6: Nervous System **3 hrs**

Comparative account of brain; Cranial nerves in mammals.

UNIT 7: Sense Organs **3 hrs**

Classification of receptors; Structure and function of mammalian eye and ear.

UNIT 8: Urinogenital System **3 hrs**

Succession of kidney; Evolution of urinogenital ducts; Types of uteri in mammals.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of different types of feathers of birds.
2. Study of the disarticulated skeleton of Frog, Varanus, Fowl, Rabbit (Vertebral Column, Sternum,Girdles, Ribs, Limb bones).
3. Study of the vertebrate Skull (i) one herbivorous and one carnivorous animal skull; (ii) one monocondylic and one dicondylic skull.
4. Study of carapace and plastron of turtle/tortoise.
5. Study of the digestive, circulatory and urinogenital system of frog/rat through videos ondissection or through virtual dissections.
6. Project related to topics covered in theory.
7. Field trips/Documentary film show on vertebrates/Visit to Zoological Park, Biodiversity Park or Sanctuary.

8. Student Presentation: Power point presentation on any two animals from two different classes.

Essential/recommended readings

1. Kardong, K.V. (2005) Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.

2. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.

Suggestive readings

1. Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001) Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.

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

DISCIPLINE SPECIFIC CORE COURSE -11 – : Developmental Biology Zoo-DSC-11

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		
Developmental Biology Zoo-DSC-11	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	Basic knowledge of Chordates

Learning Objectives

The learning objectives of this course are as follows:

- to provide an in-depth knowledge on the embryonic and post embryonic developmental processes.
- to apprise the students of the fascinating aspect of the development of a single fertilized egg to mature into a fully developed complex organism.
- to explain the basic principles and concepts the developmental processes from a single cell system to a multi-cellular system.
- to understand morphogenesis in Sea urchin, Drosophila, Frog and Chick.
- to provide the undergraduate students an in-depth knowledge on the embryonic

and post embryonic developmental processes.

- by understanding the developmental processes, the students can relate to errors occurring during development leading to congenital disorders and human diseases.
- to familiarize the students with the technique of IVF and pre-diagnostic methods to identify any abnormality arising during development.
- To make the students aware of the areas of great interest including stem cell therapy, tissue engineering and regenerative medicine.

Learning Outcomes

By studying this course, students will be able to

- appreciate the events that lead to the formation of a multicellular organism from a single fertilized egg.
- better understand the general patterns and sequential developmental stages during embryogenesis.
- gain knowledge of the general mechanisms involved in morphogenesis.
- comprehend the processes of ageing to improve the overall health and quality of life in aged people.
- acquire basic knowledge and importance of latest techniques like stem cell therapy, *in vitro* fertilization and amniocentesis etc.
- develop the skill to raise and maintain culture of model system- *Drosophila* in the laboratory.

Syllabus of DSC-11

UNIT- 1: Introduction **2 hrs**

Historical perspectives and basic concepts: Phases of development, Pattern formation, Differentiation and growth, Cytoplasmic determinants.

UNIT- 2: Early Embryonic Development **12 hrs**

Gametogenesis: oogenesis, spermatogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal), Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps; Gastrulation in frog and chick, Embryonic induction and organizers.

UNIT- 3: Late Embryonic Development **6 hrs**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, structure, types, and functions of placenta.

UNIT- 4: Post Embryonic Development **6 hrs**

Metamorphosis and its hormonal regulation in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: concepts and theories.

UNIT- 5: Implications of Developmental Biology **4 hrs**

Teratogenesis: Teratogenic agents and their effects on embryonic development; *in-vitro* fertilization, Embryonic stem cell (ESC), Amniocentesis.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula (Neural plate, Neural fold and Neural tube stages), tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7- 24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19- 72 hours and Stage 24-96 hours of incubation
3. *in vivo* study of chick embryo development by windowing and candling methods. (Demonstration only)
4. Study of indirect development and metamorphosis by rearing any one insect.
5. Study of different sections of placenta (photomicrographs/ slides).
6. Project report on *Drosophila* or any insect culture/Visit to Poultry Farm/IVF Centre
7. Student Presentation: Power point presentation on any topic related to developmental biology.

Essential/recommended readings

1. Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.
2. Gilbert, S. F. (2010) Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
3. Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
4. Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.

Suggestive readings

1. Baweja, V. and Misra, M. (2021) E-book on Practical Manual of developmental Biology.
2. Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company.
3. Wolpert, L. (2002) Principles of Development. II Edition, Oxford University Press.
4. Kalthoff, K. (2001) Analysis of Biological Development. II Edition, McGraw Hill Publishers.

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

DISCIPLINE SPECIFIC CORE COURSE– 12:
Animal Behaviour Zoo-DSC-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 (if any)
		Lecture	Tutorial	Practical		
Animal Behaviour Zoo-DSC- 12	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**

Learning Objectives

The learning objectives of this course are as follows:

- To provide an overview of animal behaviour in a scientific study of the wild and the wonderful ways in which animals interact with each other, with other living beings, and with the environment.
- to understand and appreciate different types of animal behaviour, their adaptive and evolutionary significance.
- to equip the students with an ability to pursue career in behavioural ecology other related areas.
- to apprise the students of the versatility of Animal behaviour and its crosstalk among conservation biology, molecular biology, behavioural ecology and integrated pest management.

Learning Outcomes

By studying this course, students will be able to:

- comprehend various types of animal behaviour and their importance.
- observe, analyse, interpret and document the different types of behaviour.
- enhance their skills by taking short projects pertaining to Animal behaviour.
- appreciate and develop passion to biodiversity; and respect the nature and environment.
- better understand and relate the fundamentals and advanced concepts so as to develop a strong foundation that will enable them to acquire skills and knowledge.

SYLLABUS OF DSC-12

UNIT- I Introduction to Animal Behaviour **4 hrs**

Origin and history of ethology; Pioneers of modern ethology: Karl *von* Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate causes of behavior.

UNIT- 2 Mechanisms of Behaviour **5 hrs**

Innate behaviour, Instinct, Stimulus filtering, Sign stimuli, Code breakers.

UNIT- 3: Patterns of Behaviour **5 hrs**

Orientation: Primary and secondary orientation; Kinesis - orthokinesis, klinokinesis; **Taxis**: tropotaxis and klinotaxis, menotaxis (light compass orientation).

Learning: Associative learning, Classical and operant conditioning, Habituation, Imprinting;

Reasoning: Intelligence and artificial intelligence.

UNIT- 4: Communication **3 hrs**

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

UNIT- 5: Social Behaviour **4 hrs**

Concept of Society; Insects' society; Honey bee: Society organization, polyphenism and polyethism; Foraging in honey bee, round dance, waggle dance; Experiments to prove distance and direction component of dance; Formation of new hive/queen.

UNIT- 6: Altruism **3 hrs**

Altruism, Inclusive fitness, Hamilton's rule

UNIT 7: Sexual Behaviour **6 hrs**

Asymmetry of sex; Sexual dimorphism, mate choice; Intra-sexual selection (male rivalry); Inter- sexual selection (female choice); Courtship behaviour, Courtship behavior in 3-spine stickleback; Infanticide; Parental care, sexual conflict in parental care.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Tools, techniques and methods used in studying animal behavior.
2. To study nests and nesting behaviour of the birds and social insects.
3. To study the behavioural responses of wood lice to dry and humid conditions.
4. To study geotaxis behaviour in earthworm.
5. To study the phototaxis behaviour in insect larvae.
6. To study different types of animal behaviour such as habituation, social life, courtship behaviour in insects and birds, and parental care from short videos/movies. At least two videos for each behaviour.
7. Construction of ethogram using suitable data to study animal behaviour.
8. Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record the behavioural activities of animals and prepare a short report.

Essential/recommended readings

1. John Alcock, (2013) Animal Behaviour, Xth Edition, Sinauer Associates Inc., USA.
2. Manning, A. and Dawkins, M. S, (2012) An Introduction to Animal Behaviour, VI th 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. David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.

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POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES

SEM IV

DISCIPLINE SPECIFIC ELECTIVES (DSE-5): Bioenergetics and Enzymology
Zoo-DSE-5

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			
Bioenergetics and Enzymology Zoo-DSE-5	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic knowledge of Biochemistry**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to develop a holistic understanding of the complex enzymatic reactions occurring within body through lectures, practical and laboratory exercises, assignments, seminars and visit to research Institutes.
- to appreciate the basic laws of thermodynamics; free energy, and equilibrium to acquire the knowledge to introspect and understand the core concepts of biochemistry
- to build upon undergraduate-level knowledge of biochemical principles with specific emphasis on concepts of transfer of energy in different metabolic pathways.
- to learn about the basic tools used over and over in biological reactions.

Learning Outcomes

By studying this course, students will be able to

- differentiate between the "high energy" biomolecules with respect to their hydrolysis and group transfers.
- appreciate the energy stored in reduced organic compounds that can be used to reduce cofactors such as NAD^+ and FAD, which serve as universal electron carriers.
- Increase the understanding of the function of electron-transport chain in mitochondria and the chemi-osmotic theory involved in ATP synthesis.
- explain the thermodynamic basic principles for energy transformation in biological membranes.

- use spectroscopic and other physical analytical methods to use membrane proteins and biological redox processes.

SYLLABUS OF DSE-5

UNIT- 1: Principles of Biophysical Chemistry **5 hrs**

Concept of pH, buffers, Principles of thermodynamics: free-energy, entropy, enthalpy, chemical bonds and stabilizing interactions: van der Waals, electrostatic, hydrogen bonding and hydrophobic interactions.

UNIT- 2: Bioenergetics: **9 hrs**

Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation between standard reduction potentials and free energy change.

High energy phosphate compounds- introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG.

Transfer of energy: Electron Transport Chain, Bioenergetics of the liver.

UNIT- 3: Kinetics of enzyme action **10 hrs**

Concept of ES complex, Derivation of Michaelis-Menten equation for uni-substrate reactions. Different plots for the determination of Km and V_{max} and their physiological significances. Importance of K_{cat}/K_m. Kinetics of zero and first order reactions.

Classification of multi substrate reactions with example of each class. Ping Pong random and ordered BiBi mechanisms. Use of initial velocity, inhibition and exchange studies to differentiate between multi substrate reaction mechanisms.

Reversible (glutamine synthase and phosphorylase) and irreversible (proteases) inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, Suicide inhibitor.

UNIT- 4: Mechanism of Enzyme Action **8 hrs**

Cofactor dependency, pH, temperature and ionic strength dependency; Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain and distortion theory. Chemical modification of active site groups. Mechanism of action of chymotrypsin.

UNIT V: Enzyme Regulation **7 hrs**

Feedback inhibition and feed forward stimulation; Allosteric enzymes: qualitative description of "concerted" & "sequential" models for allosteric enzymes;
Half site reactivity, Flip-flop mechanism, positive and negative co-operativity.

UNIT VI: Multi-enzyme system: **6 hrs**

Occurrence, isolation and their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Titration of a weak acid using a pH meter, preparation of buffers
2. Verification of Beer-Lambert's law and determination of absorption coefficients.
3. Preparation of cytochrome C from goat/chicken heart and distinguish between different cytochromes in ETC using absorbance spectra.
4. Isolation of NAD from brewer's yeast. Calculate Gibbs' Free Energy for electron flow from reduced NADH to Oxygen.
5. Assay of enzyme activity and specific activity, e.g. acid phosphatase, alkaline phosphates, SGOT, SGPT.
6. Determination of K_m and V_{max} using Lineweaver-Burk graph. (Dry experiment).
7. Enzyme inhibition - calculation of Ki for competitive inhibition. (Dry experiment)
8. Perform complex energy calculations that can be applied to biological systems. (Dry experiment)

Essential/recommended readings

1. Lehninger by D. Nelson, and M. Cox, (2017) "The principles of Biochemistry", 7 th edition, M.W.H. Freeman and Company, New York.
2. D. M. Greenberg, (2014) "Metabolic Pathways", 3rd edition, Academic Press, Elsevier Science & Technology Books,
3. David G. Nicholls and Stuart J. Ferguson (2013) "Bioenergetics 4", Academic Press.
4. L. Stryer, (2012) "Biochemistry", 7 th edition, W.H. Freeman and Company, New York.

Suggestive readings

1 J. M. Berg, J. L. Tymoczko, L. Stryer (2007) "Biochemistry", 6th edition, W. H. Freeman and Company, New York, NY, 2007.
2. D.J. Voet, J.G. Voet, C.W. Pratt, (2008) "Principles of Biochemistry" 3rd edition, John Wiley & Sons, Inc.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-6): Cell Growth and Regulation
Zoo-DSE-6

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/ Practice			
Cell Growth and Regulation Zoo-DSE- 6	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic knowledge of Cell Biology**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to enable students to learn biological phenomenon at cellular level
- to develop an understanding of cell function and its regulatory mechanisms.
- to understand cell division, cell cycle and its regulation, growth factors, survival factors; cell cycle control systems and checkpoints.
- to provide in-depth knowledge on various experimental skills and histo-pathological studies used in clinical and research laboratories
- to acquire knowledge in the areas of cellular malfunctioning causing serious health conditions such as autoimmune disorders, cancers etc.

Learning Outcomes

By studying this course, students will be able to:

- appreciate the diverse cellular processes, cell signaling, and cellular interactions.
- Know more about the defects in cellular functioning and molecular mechanisms that can lead to diseases and disturb the homeostasis of the body.
- to elucidate the roles of cell signalling in gene regulation
- appreciate differences in normal and cancer cell, apoptosis vs. necrosis; cell death and cell renewal
- observe stem cells and their applications in therapeutic cloning and regenerative medicine.
- Know the fundamentals of targeted cancer therapies and molecular approaches to cancer treatment.

SYLLABUS OF DSE- 2

UNIT 1: Cell division, Cell Cycle, and its Regulation **10 hrs**

A brief study of stages and events during mitosis and meiosis; overview of cell cycle; mitogens, growth factors, and survival factors; cell cycle control system: components and mechanisms; cell cycle checkpoints.

UNIT- 2: Cell Signalling **7 hrs**

Types of cell-cell signalling, signalling molecules, and cell receptors; components of a generalized signalling pathway; examples of two pathways: GPCR/ cAMP/ PKA/ CREB/ target gene and a nuclear receptor pathway (to elucidate roles in gene regulation).

UNIT 3: Gene Regulation **9 hrs**

Concepts of positive and negative gene regulation; principles of eukaryotic transcriptional regulation of genes; concepts of activators, repressors, silencers, and enhancers.

UNIT- 4: Cell Death and Cell Renewal **9 hrs**

Apoptosis *vs*. necrosis; intrinsic and extrinsic pathways of programmed cell death; stem cells and maintenance of adult tissues; cells in culture and cell lines; embryonic and induced pluripotent stem cells and their applications in therapeutic cloning and regenerative medicine.

UNIT 5: Cancer Biology **10 hrs**

Hallmarks of a cancer cell; types and causes of cancer; oncogenes and tumour suppressor genes; tumour viruses; correlation of cell signaling, gene regulation, cell cycle control, and cell death in cancer development (any one example); targeted cancer therapies/molecular approaches to cancer treatment.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Principles of Microscopy.
2. Preparation of a temporary slide of onion root tip to study various stages of mitosis.
3. Study of various stages of meiosis through permanent slides.
4. Cell culture techniques: preparation of media, seeding, thawing and maintenance of cell culture, trypsinization and cryopreservation
5. Measurement of cell growth: Direct count by Trypan blue and Indirect count by Spectrophotometer.
6. Calculation of Doubling Time based on given data.
7. Assessment of metabolic activity by MTT.
8. Study of monolayer (in Roux Bottle, Roller bottle, Plastic film, Optical culture system, Bread Bed reactors, Heterogenous reactors). Suspensions (stirred bioreactors, continuous flow cultures, air lift fermenter) and immobilized cultures.

9. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
2. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

Suggested readings

1. Alberts et. al., (2008) Molecular Biology of the Cell, Garland Science, Taylor & Francis Group, New York, USA.

2. Lodish et. al., (2007) Molecular Cell Biology, W.H. Freeman and Company, New York, 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-7):
Fish and Fisheries Zoo-DSE-7

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			
Fish and Fisheries Zoo-DSE- 7	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Nil**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- To offer an insight about the climatic conditions that favours fish growth and reproduction.
- to understand the importance of fish as a rich source of animal protein.
- To learn the basic concepts and knowledge of fish biology and its applications.
- to equip the student with a balanced and complete scientific understanding of fisheries.
- to enable students to learn more technical skills to generate entrepreneurial skills and suitable employment opportunities.
- to acquire knowledge of the pathogenic and pathological basis of fish diseases including infectious diseases caused by viruses, prokaryotes, protozoans, helminthes, vector borne and zoonotic diseases.
- To learn about nutritional deficiencies and lifestyle diseases, endocrine diseases and cancer.

Learning Outcomes

By studying this course, students will be able to:

- acquire basic knowledge of physiology and reproduction in fishes.
- analyse different kinds of water and identify/differentiate among various kinds of fishes.
- equip the students with the knowledge on the procedures for artificial and induced breeding which can be learnt by visiting any fish farm or demonstrated in research labs in college/Departments.
- have more knowledge of the in-land and marine Fisheries in India and to explore ways in which it can contribute to the Indian economy.
- know more about the different methods of fishing and fish preservation

which can be employed for export and storage of commercial fishes.

- develop skills for entrepreneurship or self-employment in fisheries-related business.

SYLLABUS OF DSE- 7

UNIT– 1 Introduction and Classification **6 hrs**

General description of fish; Account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction. Brief introduction to transgenic fishes.

UNIT– 2 Morphology, Physiology and Behavior **14 hrs**

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales,Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy;Osmoregulation in Elasmobranchs, Schooling; Parental care; Migration.

UNIT– 3 Fisheries **8 hrs**

Inland Fisheries; Estuarine Fisheries, Marine Fisheries; Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Fisheries law and regulations.

UNIT – 4 Aquaculture **17 hrs**

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish;Management of finfish hatcheries; Preparation of compound diets for fish; Role of water quality in aquaculture; Post harvest handling techniques and Fishery by-products.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Study of specimens- *Petromyzon*, *Myxine*, *Pristis*, *Chimaera, Exocoetus*, *Hippocampus*,*Gambusia, Labeo, Heteropneustes, Anabas* (at least one fish from each class).
2. Study of different types of scales by preparing a temporary/permanent mount.
3. Study of air breathing organs in *Channa, Heteropneustes, Anabas* and *Clarias.*
4. Demonstration of induced breeding in Fishes and hatchery management (video/visit tofisheries institute/fish farm).

Demonstration of the setting up of a fish aquarium, and its management/maintenance.

5. Study of parental care in fishes through visual media and resources.
6. Study of different methods of fish tagging.
7. Determination of fish density in a pond by Peterson's mark recapture method.
8. Project Report on a visit to any fish farm/pisciculture unit.

Essential/recommended readings

1. Pandey, K. and Shukla, J.P. (2013) Fish and Fisheries. Rastogi publication,India
2. Chakrabarti, R. and Sharma, J. G. (2008). Aquahouse: New Dimension of Sustainable Aquaculture. DIPAS, Indian Council of Agricultural Research, New Delhi, India.
3. Norman, J.R. A History of Fishes. Hill and Wang Publishers. Khanna, S.S.and Singh, H.R. (2014) A text book of Fish Biology and Fisheries. Narendra, Publishing House.
4. Bone, Q. and Moore, R. (2008) Biology of Fishes. Talyor and Francis Group, CRC Press, U.K.

Essential/recommended readings

1. Srivastava, C.B.L. (2008) Fish Biology. Narendra Publishing House.
2. Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan Publication Cooperation. India.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-8):
Parasitology Zoo-DSE-8

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/ Practice			
Parasitology Zoo-DSE- 8	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic under-standing of parasitic animals**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- To enable the students to see, appreciate and understand the diversity of parasites
- to learn about Parasitology that will enable students to diagnose parasites correctly, understand their life cycle and control them effectively and use some of them as bio control agents
- to acquire understanding of study of life cycles of parasites, that can help in defying the stigmas and religious taboos for many societies making free many of the people from superstition and ill health.
- to make the students aware about the possible scope of the subject which includes research and applied aspects including entrepreneurial skill

Learning Outcomes

By studying this course, students will be able to:

- better understand the variation amongst parasites, parasitic invasion in animals; applicable to medical and agriculture aspects
- Identify the stages of the life cycles of parasites and their respective infective stages. develop ecological model, on the base knowledge of population dynamics of parasites.
- comprehend the different methods adopted by parasites to combat with the host immune system.
- develop skills and realize significance of diagnosis of parasitic attack and treatment of patient or host.

- analyse and interpret the case studies to highlight innovative researches, serendipities towards the advancement and enrichment of knowledge in the field of Parasitology.

SYLLABUS OF DSE- 8

UNIT- 1: Introduction to Parasitology **3 hrs**

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors; Host parasite relationship

UNIT- 2: Parasitic Protists **10 hrs**

Study of Morphology, Life Cycle, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica, Trypanosoma gambiense and Plasmodium vivax.*

UNIT- 3: Parasitic Platyhelminthes **10 hrs**

Study of Morphology, Life Cycle, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Fasciolopsis buski, Schistosoma haematobium* and *Taenia solium*

UNIT- 4: Parasitic Nematodes **10 hrs**

Study of Morphology, Life Cycle, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*.

UNIT- 5: Parasitic Arthropoda **8 hrs**

Biology, importance and control of ticks, mites, *Pediculus humanus* (Head and Body louse), *Xenopsylla cheopis* and *Cimex lectularius*

UNIT- 6: Parasitic Vertebrates **4 hrs**

A brief account of parasitic vertebrates; Cookicutter Shark, Hood Mockingbird and Vampire bat.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Study of life stages of *Entamoeba histolytica, Trypanosoma gambiense*, and *Plasmodium vivax* through permanent slides/micro photographs.
2. Study of adult and life stages of *Fasciolopsis buski, Schistosoma haematobium* and *Taenia solium* through permanent slides/microphotographs.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostoma duodenale* and *Wuchereria bancrofti* through permanent slides/microphotographs.
4. Study of *Pediculus humanus* and *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.

5. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by-product of the industry]
6. Submission of a brief report on parasites (anyone phylum).
7. Visit to rural area/hospital near rural area/NCDC/NIMR/NICD to study the natural history and diagnostics of parasites.

Essential/recommended readings:

1. Parija, S. C. (2013) Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), IV Edition, All India Publishers & Distributers, New Delhi.
2. Ichhpujani, R.L. and Bhatia, R. (2009) Medical Parasitology. III Edition, Jaypee BrothersMedical Publishers (P) Ltd., New Delhi
3. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor andFrancis Group.

Suggested readings:

1. Chatterjee, K. D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBSPublishers & Distributors (P) Ltd.
2. Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications andDistributors
3. Noble, E.R. and Noble, G.A. (1989) Parasitology: The Biology of Animal Parasites. VIEdition, Lea and Febiger

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-8): Exploring Animal World
Zoo-GE-8

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Exploring the Animal world Zoo-GE-8	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- to overview the concepts of invertebrate and vertebrate animals, including sponges, cnidarians, comb jellies, flatworms, nematodes, annelids, molluscs, arthropods, echinoderms, invertebrate chordates, fishes, amphibians, reptiles, birds, and mammals.
- to enable students to understand the diversity within different groups, and interrelationship among different species and genera within each group of animals.
- to learn the hierarchy, body plan and their role in ecological development of animals.

Learning Outcomes

By studying this course, students will be able to

- Learn about the importance of systematics, taxonomy, and structural organization of non-chordates and chordata.
- Appreciate the diversity of animals living in varied habits and habitats.
- Understand evolutionary history and relationships of different animals through functional and structural affinities.
- better understand coelom formation, different levels of organization, role of macronutrients and micronutrients, their nutritional requirements for different age groups during various health conditions.

SYLLABUS OF GE-8

UNIT- 1: An Introduction to the Animal Kingdom **2 hrs**

Non-chordates *vs.* Chordates; Outline of Coelom, Body symmetry, Levels of organization

UNIT-2: Kingdom Protista **2 hrs**

General characters of Protozoa; Locomotory organelles

UNIT- 3: Porifera **2 hrs**

General characters of Phylum Porifera, Canal system in Porifera

UNIT- 4: Radiata **2 hrs**

General characters of Phylum Cnidaria & Ctenophora; Polymorphism

UNIT- 5: Helminthes **3 hrs**

General characters of helminths (Platyhelminthes and Nemathelminths); Parasitic Adaptations

UNIT- 6: Coelomates (Non-chordates) **6 hrs**

General characters of Phylum Annelida; Metamerism
General characters of Phylum Arthropoda; Vision in insects
General characters of Phylum Mollusca; Pearl Formation
General characters of Phylum Echinodermata, water vascular system in starfish

UNIT- 7: Lower chordates (Protochordata) **1 hr**

Salient features of Protochordates (Hemichordates, Urochordates and Cephalochordates)

Unit 8: Higher chordates **12 hr**

General characters of Vertebrates:

- Cyclostomes; Cartilaginous and Bony fishes; Catadromous and Anadromous migration.
- Amphibians; Adaptations for Terrestrial Life
- Reptiles; Poisonous and Non-poisonous Snakes
- Aves; Flight Adaptations in birds
- Mammals - Prototheria, Metatheria and Eutheria.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of specimens- Non-chordates:

Euglena, Noctiluca, Paramecium; Sycon; Physalia, Tubipora, Meandrina; Taenia, Ascaris; Nereis, Heteronereis, Aphrodite, Hirudinaria, Peripatus; Limulus, Cancer, Daphnia, Julus, Scolopendra, Apis, Termite; Chiton, Dentalium, Octopus; Asterias and *Antedon*

2. Study of specimens- Chordates:
Balanoglossus, Herdmania, Amphioxus; Petromyzon; Sphyrna, *Pristis, Hippocampus, Exocoetus, Diodon/ Tetradon; Icthyophis/ Uraeotyphlus, Bufo, Hyla, Salamandra; Rhacophorus, Draco, Uromastix, Naja, Viper*;
Any three common birds (Crow, duck, Owl); Funambulus, Loris and Bat

3. Study through Permanent Slides:
i) Cross Section of *Sycon*, and *Ascaris* (male and female).
ii) T. S. of Earthworm passing through Pharynx, Gizzard, and Typhlosole region of intestine.
iii) Septal and Pharyngeal Nephridia of Earthworm.
iv) Placoid and Cycloid Scales in Fishes.

4. Study of Organ Systems (through videos/animations/photographs/dissections*:
i) Digestive System of Cockroach;
ii) Urinogenital System of Rat
* subject to UGC guidelines

Essential/recommended readings

1. Young, J.Z. (2004) The Life of Vertebrates. III Edition, Oxford University Press.
2. Ruppert, Fox and Barnes (2003) Invertebrate Zoology. A Functional Evolutionary Approach, VII Edition, Thomson Books/Cole.
3. Parker T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates. VII Edition, Volume II. Blackwell, Hoboken

**Note: Refer Ruppert, Fox and Barnes (VII Ed.) for the classification of invertebrates;*

Suggestive reading

1. Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd.
2. Campbell and Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
3. Mann Raven, P.H. and Johnson, G.B. (2004). Biology, VI Edition, Tata McGraw Hill Publications. New Delhi.

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

GENERIC ELECTIVES (GE-9): Microbiota: Importance in Health and Disease Zoo-GE-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			
Microbiota: Importance in Health and Disease Zoo-GE-9	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 of microbiota that coexist with the human being both in health and in different pathologies.
- To enable students to understand how microbiota undergoes changes as a consequence of the influence of multiple factors, diet, lifestyle, pharmacological treatments generating alterations in this bacterial ecosystem.
- To compare the role of our microbiota in behavior, mood, and development.
- to make the students aware of the microbial communities that reside within or upon us, and how they impact our health.
- To acquire knowledge about the interactions between the different types of microbiota and their host in different pathophysiological situations.

Learning Outcomes

By studying this course, students will be able to

- Identify the components of the human microbiota and their major characteristics.
- Learn the key approaches and techniques used to identify and quantify the bacterial, fungal, archaeal, protozoan, and viral components of the microbiota.
- Identify the common members of the microbiota and their influence on various body systems including the skin, upper and lower respiratory system, oral and the lower digestive system, urinary and reproductive systems, the immune system, and the nervous system in healthy and diseased states.
- Compare the role of our microbiota in behavior, mood, and development.
- Appreciate the emerging treatment approaches for microbiota-associated illnesses.

SYLLABUS OF GE-9

UNIT- 1: Microbes **4 hrs**

Introduction to microbes, general approaches and techniques used for studying microbiota, the nature of microbiological problems, Prokaryotic and eukaryotic organisms.

UNIT- 2: Introduction to the Human Microbiome **16 hrs**

Importance of human body environment for growth of a variety of microorganisms, concept of contamination, infection and disease, septicaemia, Acute and subacute bacterial endocarditis.

a) Microbial Diseases of the Respiratory System: Tuberculosis; Common cold,

b) Microbial Diseases of the Eyes: Conjunctivitis, Trachoma; Viral Diseases of the Eye.

c) Microbial Diseases of skin: Bacterial diseases of the skin: Acne, folliculitis, boils, cellulitis, Infections of burns and surgical wounds, gangrene, Leprosy. Viral Diseases of the Skin: Chicken pox;

Fungal Diseases of the Skin: Candidiasis.

d) Microbial Diseases of the Nervous System: Bacterial diseases: Tetanus, Viral diseases: Polio/Rabies; Protozoan diseases: Trypanasomiasis

e) Microbial Diseases of the Oral Cavity and Digestive System: Bacterial diseases: Dental caries; Cholera, Gastroenteritis; Fungal diseases: Aflatoxin poisoning, Ergot poisoning; Viral diseases: Mumps; Protozoan diseases: Amoebic dysentery, Giardiasis

f) Microbial Diseases of the Urinary/Reproductive Systems: Bacterial diseases: Syphilis; Viral diseases: genital warts; Protozoan diseases: Trichomoniasis; Fungal diseases: Vaginitis

UNIT- 3: Microbiota and the Immune System Development **5 hrs**

Normal flora, transient flora opportunistic microbes, Pathogenicity, virulence, and factors that increase virulence (enzymes, toxins), Factors that affect the spread of disease, Nonspecific immune responses, Specific immune responses: humoral and cell mediated immunity

UNIT- 4: Human Microbiota in Health and Disease **5 hrs**

Basic concept of Gut microbiota in the mother-child environment, Gut microbiota and cancer; Microbiota and viral diseases- An opportunity for COVID-19. Relationship between diet and the intestinal microbiota, Probiotics, prebiotics and other "biotics".

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Bacterial shapes and arrangements Cell wall, Cell membrane, Glycocalyx, Endospores, Flagella, Cytoplasmic inclusions, Cytoplasmic structures/organelles, Bacterial growth curve, Physical factors affecting microbial growth.
2. To understand Good Lab practise: The effectiveness of hand washing and sterilization.
3. To understand microbial morphology by Gram Staining.
4. To appreciate bacterial anatomy by Acid-fast Staining.
5. Environmental Factors affecting growth of microorganisms: Temperature, pH and Osmotic Pressure.
6. Bacterial growth curve and evaluation of factors affecting microbial growth.
7. Isolation of normal microbiota from the human Body (Nose, Throat, or Skin).
8. Effects of chemical agents on bacteria growth (Kirby-Bauer method).

Essential/recommended readings

1. Leboffe, M. J and Pierce; B. E. (2014) A Photographic Atlas for the Microbiology Laboratory, 5th Edition, Morton Publishing Company.
2. Michael Wilson (2005) "Microbial Inhabitants of Humans-Their Ecology and Role in Health and Disease"; Oxford University Press, UK.

Suggestive readings

1. Nina Parker, Mark Schneegurt, Anh-Hue-Thi Tu and Brian M. Forster; (2016) "Microbiology"; 1st Edition, OpenStax Resource.

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

GENERIC ELECTIVES (GE-10): Insect Vector and Disease
Zoo-GE-10

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/ Practice			
Insect Vector and Disease Zoo-GE-10	**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 a variety of diseases caused by insects.
- to learn the complex interactions between the transmission by Insect-borne pathogens affecting human health.
- to acquire knowledge of how the insects can only be controlled and prevented by studying their biology, modalities of pathogen transmission
- to enable students to evaluate the associated risk factors and devising new efficient techniques to control these insects.
- to help understand the environmental pressures caused by stagnant water.
- to motivate students to pursue a career in Health Management.

Learning Outcomes

By studying this course, students will be able to

- identify different insects and classify them based on their morphology and behaviour.
- describe the host-pathogen relationships and the role of the host reservoir on transmission of parasite.
- explain various modes of transmission of parasite by insect vectors.
- recognize various possible modern tools and methodologies for laboratory diagnosis, surveillance and treatment of diseases.
- develop a critical understanding of insect transmitted diseases such as Zoonotic, Vertical and Horizontal transmission, host specificity etc.
- spread awareness on public health programs about insect borne diseases and their control.

- To use advanced management strategies in disease control with respect to parasite evolution

SYLLABUS OF GE-10

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

General Features of Insects, Classification of insects up to Orders- General features of orders, Morphological features: Head, legs and types of antennae. Types of Insects mouth parts w.r.t. feeding habits: siphoning type (butterfly), sponging type (housefly), biting and chewing type (cockroach), piercing and sucking type (mosquito), chewing and lapping type (honey bee).

UNIT- 2: Concept of Vectors **5 hrs**

Brief introduction to carriers and vectors (mechanical and biological vector); Insect reservoirs; Host-vector relationship; Vectorial capacity; Host Specificity; Modes of disease transmission - vertical and horizontal transmission. Insects as vectors: General adaptations in insects to act as vectors.

UNIT- 3: Dipterans as disease Vectors-I **7 hrs**

Dipterans as important insect vectors–Mosquitoes. Study of mosquito borne diseases– Malaria, Dengue, Chikungunya, Filariasis, Viral encephalitis. Control and prevention/cure of diseases caused by mosquitoes. Study of sand fly-borne diseases- Visceral Leishmaniasis, Cutaneous Leishmaniasis; Control of Sand fly; Study of house fly as important mechanical vector, Control of house fly.

UNIT- 4: Siphonapterans as disease vectors **5 hrs**

Fleas as insect vectors; Study of flea borne diseases – Plague, typhus fever; Control and prevention/cure of diseases caused by fleas.

UNIT- 5: Siphunculata as disease vectors **5 hrs**

Human louse (head, body and pubic louse) as disease vectors; study of louse borne diseases – Typhus fever, relapsing fever, vagabond's disease, phthiriasis; Control of human louse and prevention/cure of diseases caused by them.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of different kinds of mouth parts and legs of insects through slides/specimens
2. Study of insect vectors through permanent slides or photographs: Mosquitoes (*Aedes, Culex, Anopheles*), lice [head, body (*Pediculus*), pubic (*Pthirus*)], Flea (*Xenopsylla cheopis*), sand fly (*Phlebotomus*), house fly (*Musca domestica*)

3. Study of different diseases transmitted by above insect vectors using photographs.
4. Project report on any one disease transmitted by insect vector.
5. Optional field trip/Lab. visit to institutes such as NIMR, NCDC.

Essential/recommended readings

1. Mullen and Darden (2009) Medical and Veterinary Entomology, 3rd Edition, Academic Press.
2. Service, M.W. (1980) A Guide to Medical Entomology, Macmillan Press.

Suggestive readings

1. Burgess, N.R.H and Cowan, G.O. (1993) A colour atlas of medical entomology. Springer Science and Business Media, B. V. House.

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SEMESTER-V
ZOOLOGY
DEPARTMENT OF ZOOLOGY
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 using Chi-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.

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 forward gene 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.

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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.

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