डॉ० राममनोहर लोहिया अवध विश्वविद्यालय, अयोध्या (उ०प्र०)

I

Dr Rammanohar Lohia Avadh University. Ayodhya U.P.

Recommendation of new syllabus of

ZOOLOGY

to be effective from session 2025-26

(Prepared as per guidelines issued by letter no.
लो॰ अ॰ वि॰/शैक्षणिक/4273/2025 dated 29/03/2025)

We unanimously propose the implementation of new syllabus from the session 2025-26 for UG/FYUP and PG programme in ZOOLOGY as modified/updated by us, the members of BOS of Zoology.

26/5/2025

26/5/25

26.05.25

DR RAMMANOHAR LOHIA AVADH UNIVERSITY, AYODHYA

UG/FYUP and PG Programme in Zoology
(Syllabus Developed by BoS Zoology)

Name of BoS Convenor and Members	Designation	Affiliation
Prof. R N Singh	Convenor	Principal, Sant Tulsidas PG College. Kadipur, Sultanpur
Prof. Mukul Sinha (Retd)	Member	Department of Zoology, LBSPG College, Gonda
Prof. A K Singh	Member	Department of Zoology, BHU, Varanasi
Prof. R K Pandey	Member	Principal, GVPPG College, Jaunpur
Prof. Shri Prakash	Member	Department of Zoology, Kulbhaskar PG College, Prayagraj
Prof. P. H. Pathak (Retd)	Member	Department of Zoology, DDU Gorakhpur University, Gorakhpur
Dr Rajiv Kumar Singh	Member	Principal Scientist, NBFGR, Lucknow

NEP - 2020

Proposed Year wise Structure of UG Program in Zoology

Year	Semester	Course Codes	Paper Title	Credits	Teaching Hours
1 Certificate Course in parasitic infections and Public Health	I	B050101T	Diversity of Non-Chordates and Economic Zoology	06	90
	II	B050201T	Cytology, Genetics and Infectious Diseases	04	60
		B050202P	Lab on Non-Chordates and Cytogenetics	02	60
2 Diploma in Biochemistry and physiology	III	B050301T	Diversity of Chordates and Comparative anatomy	06	90
	IV	B050401T	Biochemistry and Physiology	04	60
		B050402P	Lab on Chordata and Physiology and Biochemistry	02	60
3 Degree in Bachelor of Science	V	B050501T	Evolutionary and Developmental Biology	05	75
		B050502T	Ecology, Ethology and Wildlife	05	75
	VI	B050601T	Molecular Biology, Bioinstrumentation and Biotechniques	04	60
		B050602T	Gene Technology, Immunology and Computational Biology	04	60
		B050602P	Lab on Ecology, Embryology, Biotechniques and Computational Biology	02	60

26.5.25

Subject prerequisite To study Zoology in undergraduate, a student must have studied Biology, Biotechnology or Life Science in Class 12.
Programme Objectives (POs) 1. The programme has been designed in such a way so that the students get the flavour of both classical and modern aspects of Zoology/Animal Sciences. It aims to enable the students to study animal diversity in Indian subcontinent, environmental science and behavioural ecology. 2. The modern areas including cell biology and genetics, biochemistry, physiology followed by biostatistics, Evolutionary biology, bioinformatics and genetic engineering have been included to make the study of animals more interesting and relevant to human studies which is the requirement in recent times. 3. The lab courses have been designed in such a way that students will be trained to join public or private labs.

Certificate Course in Parasitic Infections & Public Health

B. Sc. I Programme Specific Outcomes (PSOs)

PSO1	This programme aims to introduce students to animal diversity specially of invertebrates. The students will be taught about invertebrates using observational strategies, museum specimens and field reports. Students will also learn about economically important invertebrates especially parasitic protozoans, and helminths which cause various infectious diseases in man.
PSO 2	The students will learn the basic principles of genetics and how to prepare karyotypes to study the chromosomes.
PSO 3	How chromosomal aberrations are inherited in humans by pedigree analysis in families.
PSO 4	The students will have hands-on training in the techniques like microscopy, preparation of slides which will help them in getting employment in pathology labs and contribute to health care system.
PSO 5	**The Certificate courses will enable students to apply for technical positions in government and private labs/institutes.**

Diploma in Biochemistry and Physiology	
B.Sc. II Programme Specific Outcomes (PSOs)	
PSO1	This programme aims to introduce students to animal diversity especially of vertebrates. The students will be taught about vertebrates using observational strategies, museum specimens and field reports. The students will develop understanding of chordate body plan and also variation the on anatomical theme in various classes of chordates.
PSO 2	The students will be able to understand and apply the principles and techniques of biochemistry, molecular biology which prepares students for further career in molecular biology. Independently execute a laboratory experiment using the standard methods and techniques.
PSO 3	The students will learn the structure and functioning of human body in biochemical terms. They will develop basic concepts about assessing human health on the basis of levels of various molecules in blood and other body fluids. An understanding of body metabolism will enable students to appreciate the complexity, diversity and interactions in biomolecules necessary for normal functioning of body.
PSO 4	The students will get basic understanding of structural organization and functioning of organ systems like digestive system, respiratory system, circulatory system, excretory system, nervous system, muscular and reproductive system of chordates. Students will be familiarized with different apparatuses and techniques used for various diagnostic purposes.
PSO 5	**The Diploma courses will ensure employability in Hospitals/Diagnostics and Pathology labs with good hands-on training. It will also enable students to take up higher studies and Research as their career and work in renowned labs in the country and abroad.**

Degree in Bachelor of Science	
B.Sc. III Programme Specific Outcomes (PSOs)	
PSO1	• This programme aims to introduce students to animal diversity of invertebrates and vertebrates. The students will be taught about economically important animals and also about their evolution and development
PSO 2	• Comparative anatomy, physiology and biochemistry will enable students to learn chordate body plan and develop an understanding of its functioning.
PSO 3	• Inclusion of ecology will enrich students with understanding of our world which is crucial for human well-being and prosperity. This section will provide new knowledge of the interdependence between people and nature that is vital for food production, maintaining clean air and water, and sustaining biodiversity in a changing climate.
PSO 4	An understanding of gene technology and computational biology will open new horizon for students and give them idea of potential of these disciplines in solving global challenges like food scarcity, medicine/vaccine availability, pollution and climate change.
PSO 5	• The basic concepts of biosystematics, evolutionary biology and biodiversity will enable students to solve the biological problems related to environment.
PSO 6	• At the end of the course the students will be capable enough to comprehend the reason behind such a huge diversity of animals and reason out why two animals are grouped together or remain separate due to similarities and differences which exist at many levels along with ecological, environmental and cellular inputs.
PSO 7	• **The Degree courses will enable students to go for higher studies like Masters and Ph.D. in Zoology and Allied subjects.**

Programme/Class: Certificate	**Year:** First	**Semester:** First
Subject: ZOOLOGY		
Course Code: B050101T	**Course Title:** Diversity of Non-Chordates and Economic Zoology	

Course outcomes:

The student at the completion of the course will be able to:

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of non-chordate diversity
- explain structural and functional diversity of non-chordate
- explain evolutionary relationship amongst non-chordate groups
- Get employment in different applied sectors
- Students can start their own business i.e. self- employments.
- Enable students to take up research in Biological Science

Credits: 6	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:** 4-0-0

Unit	Topic	Total No. of Lectures (90)
I	**Protozoa to Coelenterate** • Protozoa – *Paramecium* (Morphology and Reproduction) • Porifera – *Sycon* (Canal System) • Coelenterata – *Obelia* (Morphology and Reproduction)	10
II	**Ctenophora to Nemathelminthes** • Ctenophora - Salient features • Platyhelminthes - *Taenia* (Tape worm) (Morphology and Reproduction) • Nemathelminthes –*Ascaris lumbricoides* (Morphology and Reproduction)	10
III	**Annelida** • Annelida –*Hirudinaria* (Leech) (Morphology and Reproduction)	10
IV	**Arthropoda** • Arthropoda – *Palaemon* (Prawn) (Morphology, Appendages, Nervous System and Reproduction)	10
V	**Mollusca to Echinodermata** • Mollusca – *Pila* (Morphology, Shell, Respiration, Nervous System and Reproduction) • Echinodermata –*Pentaceros* (Morphology and Water Vascular System)	10

VI	**Economic Zoology-1** **Vectors and pests** Life cycle and control of following pests: Gundhi bug, Sugarcane leafhopper, Pink boll worm, Termites and Mosquitoes and rodents.	20
VII	**Economic Zoology-2** **Culture of beneficial animals:** Sericulture, Apiculture, Lac-culture, Vermiculture	20

Suggested Readings:

1. Barnes et al (2009). The Invertebrates: A synthesis. Wiley Backwell 17
2. Kotpal R L: A text book of Invertebrates, Rastogi Publication, Meerut
3. Marshall: Parker &Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
4. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
5. Brusca and Brusca (2016) Invertebrates. Sinauer
6. Jan Pechenik (2014) Biology of the invertebrates. McGraw Hill
7. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford
8. Parasitology- Chatterjee
9. Parasitology- Chakraborty
10. Thomos C. Chung. General Parasitology. Hardcourt Brace and Co. Ltd. Asia, New Delhi.
11. Gerard D. Schmidt and Larry S Roberts. Foundations of Parasitology. McGraw Hill.
12. Bisht. D.S., *Apiculture*, ICAR Publication.
13. Singh S., *Beekeeping in India*, Indian council of Agricultural Research, New Delhi.
14. Pedigo, L.P. (2002). *Entomology and Pest Management*, Prentice Hall.
15. Lee, Earthworm Ecology
16. Stevenson, Biology of Earthworms
17. Destructive and Useful Insects by C. L. Metcalf
18. Sericulture for Rural Development : Hanumappa (1978), Himalaya Publication,
19. Sriculture in India Sarkar, D.C. (1988), CSB, Bangalore.

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects:

The eligibility for this paper is 10+2 with Biology as one of the subject

Suggested Continuous Evaluation Methods:
House Examination/Test: 10 Marks
Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks
Class performance/Participation: 5 Marks

Further Suggestions: None

Programme/Class: Certificate	Year: First	Semester: Second
Subject: ZOOLOGY		
Course Code: B050201T	**Course Title:** Cytology, Genetics and Infectious Diseases	

Course outcomes:

The student at the completion of the course will be able to:

- Understand the structure and function of all the cell organelles.
- Know about the chromatin structure and its location.
- To be familiar with the basic principle of life, how a cell divides leading to the growth of an organism and also reproduces to form new organisms.
- How one cell communicates with its neighboring cells?
- Understand the basic principles of genetics and how genes (earlier called factors) are inherited from one generation to another.
- Understand the Mendel's laws and the deviations from conventional patterns of inheritance.
- Comprehend how environment plays an important role by interacting with genetic factors.
- How to detect chromosomal aberrations in humans and study the pattern of inheritance by pedigree analysis in families.

Credits: 4	Core: Compulsory
Max. Marks: 25+75	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:4-0-0**

Unit	Topics	Total No. of Lectures (60)
I	**Structure and Function of Cell Organelles I** • Plasma membrane: chemical structure—lipids and proteins • Cell-cell interaction: cell adhesion molecules, cellular junctions • Endomembrane system: protein targeting and sorting, endocytosis, exocytosis **Introduction to all national and international Biologists (Zoologists) who have contributed/contributing to Zoological and Life Sciences as a mark of tribute to ancient and modern biology will be included as part of the Continuous Internal Evaluation (CIE)**	6
II	**Structure and Function of Cell Organelles II** • Cytoskeleton: microtubules, microfilaments, intermediate filaments • Mitochondria: Structure, oxidative phosphorylation • Peroxisome and ribosome: structure and function	6
III	**Nucleus and Chromatin Structure** • Structure and function of nucleus in eukaryotes • Chemical structure and base composition of DNA and RNA • DNA supercoiling, chromatin organization, structure of chromosomes • Types of DNA and RNA	8

IV	**Cell cycle and Cell Division** • Cell division: mitosis and meiosis • Cell cycle and its regulation, • Apoptosis	8
V	**Mendelism and Sex Determination** • Basic principles of heredity: Mendel's laws, monohybrid and dihybrid crosses • Complete and Incomplete Dominance • Genic Sex-Determining Systems, Environmental Sex Determination, Sex Determination in *Drosophila*, Sex Determination in Humans • Sex-linked characteristics and Dosage compensation	8
VI	**Extensions of Mendelism, Genes and Environment** • Extensions of Mendelism: Multiple Alleles, Gene Interaction • The Interaction Between Sex and Heredity: Sex-Influenced and Sex-Limited Characteristics • Cytoplasmic Inheritance, Genetic Maternal Effects • Interaction Between Genes and Environment: Environmental Effects on Gene Expression, Inheritance of Continuous Characteristics	8
VII	**Human Chromosomes and Patterns of Inheritance** • Human karyotype • Chromosomal anomalies: Structural and numerical aberrations with examples • Pedigree analysis • Patterns of inheritance: autosomal dominant, autosomal recessive, X-linked recessive, X-linked dominant	8
VIII	**Infectious Diseases** • Introduction to pathogenic organisms: viruses, bacteria, fungi, protozoa, and worms • Structure, life cycle, pathogenicity, including diseases, causes, symptoms and control of common parasites: *Trypanosoma, Giardia and Wuchereria*	8

Suggested Readings:

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
2. Alberts et al: Molecular Biology of the Cell: Garland (2002).
3. Cooper: Cell: A Molecular Approach: ASM Press (2000).
4. Karp: Cell and Molecular Biology: Wiley (2002). Pierce B. Genetics. Freeman (2004).
5. Lewin B. Genes VIII. Pearson (2004).
6. Watson et al. Molecular Biology of the Gene. Pearson (2004).
7. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis KubyKuby Immunology. W H Freeman (2007).
8. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. Roitt's Essential Immunology, 13th Edition. Wiley Blackwell (2017).
9. Shetty Nandini Immunology Introductory Textbook. New Age International. (2005)

Course Books published in Hindi may be prescribed by the Universities and Colleges

Course prerequisites: To study this course, a student must have had the subject biology in class/12th

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks
Class performance/Participation: 5 Marks

Further Suggestions: None

Programme/Class: Certificate	Year: First	Semester: Second
Subject: ZOOLOGY		
Course Code: B050202P	Course Title: Lab on Non-Chordates & Cytogenetics	

Course outcomes:

At the completion of the course students will learn Hands-on:

1. To study invertebrate diversity through museum and specimen and permanent slides.
2. To use simple and compound microscopes.
3. To prepare slides and stain them to see the cell organelles.
4. The chromosomal aberrations by preparing karyotypes.
5. To learn how chromosomal aberrations are inherited in humans by pedigree analysis in families.
6.

Credits: 2	Core: Compulsory
Max. Marks: 25+75	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P:0-0-4

Unit	Topics	Total No. of Practical Hours (60)
I	1.Study of representative museum/ specimens of various non-chordate phyla. Sycon, Euplectella, Hayalonema, Spongilla, Hydra, Aurelia, Sea Anemone, Planaria,Taenia, Fasciola, Ascaris, Nereis, Pheretima, Leech, Peripatus, Palaemon, Crab, Limulus, Scolopendra, Termite, Cicada, Grasshopper, Cockroach, Chiton, Pila, Unio, Octopus, Pearl oyster, Star fish, Holothuria, Echinus 2. Study of permanent slides of whole mounts of invertebrates. *Euglena, Paramecium, Entamoeba, Giardia, Leishmania, Trypanosoma, Plasmodium, Fasciola, Taenia (scolex and proglottids), Schistosoma, Echinococcus, Enterobius, Ancylostoma, Cimex* (bed bug) and *Pediculus* (Louse). 3.Permanent mount of wings, mouth parts and developmental stages of mosquito and house fly, Larval stages of helminths and crustaceans. Permanent preparation of ticks/ mites, abdominal gills of aquatic insects viz. Chironomus larva, dragonfly and mayfly nymphs, and antenna of housefly. 4. Study of Life cycles of Silk moth, Honey bee, and lac insects.	20
II	1. To prepare permanent slide of sponge gemmule, Obelia colony, Obelia medusa, and statocyst of Palaemon 2. To dissect out nerve ring and septal nephridia of earthworm 3. To dissect out nervous system of Cockroach/Grasshopper /Palaemon 4. To dissect out nervous system of Pila 5. Study of external appendages of and Palaemon 6. Study of segmentation in Leech and Earthworm	15

III	1. To study different cell types such as buccal epithelial cells. neurons, striated muscle cells using Methylene blue. 2. To study the different stages of Mitosis in root tip of onion. 3. To study the different stages of Meiosis in grasshopper testis. 4. To prepare molecular models of nucleotides, amino acids, dipeptides using bead and stick method.	10
V	1. Study of mutant phenotypes of *Drosophila*. 2. Preparation of polytene chromosomes. 3. Study of sex chromatin (Barr bodies) in buccal smear and hair bud cells (Human). 4. Preparation of human karyotype and study the chromosomal aberrations with respect to number, translocation, deletion etc. from the pictures provided. 5. To prepare family pedigrees.	10
VI	**Virtual Labs (Suggestive sites)** https://www.vlab.co.in https://zoologysan.blogspot.com www.vlab.iitb.ac.in/vlab www.onlinelabs.in www.powershow.com https://vlab.amrita.edu https://sites.dartmouth.edu	5

Suggested Readings:

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
2. Alberts et al: Molecular Biology of the Cell: Garland (2002).
3. Cooper: Cell: A Molecular Approach: ASM Press (2000).
4. Karp: Cell and Molecular Biology: Wiley (2002). Pierce B. Genetics. Freeman (2004).
5. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis KubyKuby Immunology. W H Freeman (2007).
6. Kesar, Saroj and Vashishta N. (2007). Experimental Physiology: Comprehensive Manual. Heritage Publishers, New Delhi

Course Books published in Hindi may be prescribed by the Universities and Colleges

Course prerequisites: To study this course, a student must have had the subject biology in class/12th
The eligibility for this paper is 10+2 from Arts/ Commerce/ Science

Suggested Continuous Evaluation Methods:

Total Marks: 25

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class performance/Participation: 5 Marks

Further Suggestions: None

At the End of the whole syllabus any remarks/suggestions: University must ensure incorporation of all 06 units including virtual labs in practical evaluation.

Programme/Class: Diploma	**Year:** Second	**Semester:** Third
Subject: ZOOLOGY		
Course Code: B050301T	**Course Title:** Diversity of Chordates and Comparative Anatomy	

Course outcomes:

The student at the completion of the course will be able to:

- Demonstrate comprehensive identification abilities of chordate diversity
- Explain structural and functional diversity of chordates
- Explain evolutionary relationship amongst chordates
- Take up research in biological sciences.

Credits: 6	**Core Compulsory/Elective**
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:** 4-0-0

Unit	Topic	Total No. of Lectures (90)
I	**Origin of Chordates & Hemichordata** • Origin of Chordates. Classification of Phylum Chordata upto the class. • Hemichordata: General characteristics, classification and detailed study of *Balanoglossus* (Habit and Habitat, Morphology, Anatomy, Physiology and Development).	6
II	**Cephalochordata and Urochordata** • Cephalochordata : General characteristics, classification and detailed study of *Branchiostoma* (*Amphioxus*) (Habit and Habitat, Morphology, Anatomy, Physiology). • Urochordata : General characteristics, classification and detailed study of *Herdmania*(Habit and Habitat, Morphology, Anatomy, Physiology and Post Embryonic Development).	12
III	**Classification and General Characteristics of Vertebrates** • General characters and Classification of different classes of vertebrates (Pisces, Amphibia, Reptilia, Aves, Mammalia) up to the order with examples. • Poisonous and Non Poisonous Snakes and biting mechanism. • Neoteny and Paedogenesis • Migration in birds • Dentition in Mammals	12
IV	**Comparative Anatomy and Physiology of Vertebrates** **Integumentary System** Structure, functions and derivatives of integument **Skeletal System** Overview of axial and appendicular skeleton, Jaw suspensorium, Visceral arches	12
V	**Digestive System** Alimentary canal and associated glands and dentition	

		12
VI	**Respiratory System** Skin, gills, lungs and air sacs; Accessory respiratory organs	12
VII	**Circulatory System** General plan of circulation, evolution of heart and aortic arches **Urinogenital System** Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri	12
VIII	**Nervous System** Comparative account of vertebrate brain; Autonomic nervous system, Spinal cord, Cranial nerves in mammals **Sense Organs** Classification of receptors Brief account of visual and auditory receptors in man	12

Suggested Readings:

1. Harvey et al: The Vertebrate Life (2006)
2. Kotpal R L: A Text book of Vertebrates, Rastogi Publications , Meerut
3. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
4. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill
5. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Young: The Life of vertebrates (3rd ed 2006, ELBS/Oxford)
9. Weichert C.K and William Presch (1970). Elements of Chordate Anatomy, Tata McGraw Hills

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects:

The eligibility for this paper is 10+2 with Biology as one of the subject

Suggested Continuous Evaluation Methods:
House Examination/Test: 10 Marks
Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks
Class performance/Participation: 5 Marks

Further Suggestions: None

At the end of the whole syllabus any remarks/suggestions:

Programme/Class: Diploma	Year: Second	Semester: Fourth
Subject: ZOOLOGY		
Course Code: B050401T	Course Title: Biochemistry and Physiology	

Course outcomes:

The student at the completion of the course will learn:

- To develop a deep understanding of structure of biomolecules like proteins, lipids and carbohydrates
- To understand the thermodynamics of enzyme catalyzed reactions.
- To understand systems biology and various functional components of an organism.
- To explore the complex network of these functional components.
- To comprehend the regulatory mechanisms for maintenance of function in the body.

Credits: 4	Core: Compulsory
Max. Marks: 25+75	Min. Passing Marks: as per rules

Unit	Topics	Total No. of Lectures (60)
I	**Structure and Function of Biomolecules** • Structure and Biological importance of carbohydrates (Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates) • Lipids (saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids) • Structure, Classification and General properties of α-amino acids; Essential and non-essential α-amino acids, Levels of organization in proteins; Simple and conjugate proteins. • Nucleic Acids: Basic structure of DNA and RNA	12
II	**Enzyme Action and Regulation** • Nomenclature and classification of enzymes; Cofactors; Specificity of enzyme action • Isozymes; Mechanism of enzyme action, Activation Energy • Factors affecting rate of enzyme-catalyzed reactions; Enzyme inhibition; • Allosteric enzymes; Regulation of enzyme action	10
III	**Metabolism of Carbohydrates, Lipids and Proteins** • Metabolism of Carbohydrates: glycolysis, citric acid cycle, gluconeogenesis, Glycogenolysis and Glycogenesis • Lipids --- Biosynthesis of palmitic acid; Ketogenesis,	8

	• β-oxidation and omega -oxidation of saturated fatty acids • Metabolism of Amino acids- Transamination, Deamination and Urea cycle • Vitamins	
V	**Digestion and Respiration** • Structural organization and functions of gastrointestinal tract and associated glands • Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins • Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood, Respiratory pigments, Dissociation curves and the factors influencing it; Control of respiration	7
VI	**Circulation and Excretion** • Components of blood and their functions • Hemostasis: Blood clotting system, Blood groups: Rh factor, ABO and MN • Structure of mammalian heart • Cardiac cycle; Cardiac output and its regulation, Electrocardiogram, Blood pressure and its regulation • Structure of kidney and its functional unit; Mechanism of urine formation	8
VII	**Nervous System and Endocrinology** • Structure of neuron, resting membrane potential • Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers • Types of Synapse • Endocrine glands and their hormones - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal • Classification of hormones, Mechanism of Hormone action	8
VIII	**Muscular System** Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus	7

Suggested Readings:

1. Nelson & Cox: Lehninger's Principles of Biochemistry: McMillan (2000)
2. Zubay*et al:* Principles of Biochemistry: WCB (1995)
3. Jain J L: Fundamentals of Biochemistry, S. Chand Publication, new Delhi
4. Murray *et al:* Harper's Illustrated Biochemistry: McGraw Hill (2003) Elliott and Elliott: Biochemistry and Molecular Biology: Oxford University Press

5. Guyton, A.C. & Hall, J.E. Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company. (2006).
6. Tortora, G.J. & Grabowski, S. Principles of Anatomy & Physiology. XI Edition John Wiley & sons (2006).
7. Christopher D. Moyes, Patricia M. Schulte. Principles of Animal Physiology. 3rd Edition, Pearson Education (2016).
8. Hill, Richard W., et al. Animal physiology. Vol. 2. Sunderland, MA: Sinauer Associates, (2004).
9. Chatterjee C C Human Physiology Volume 1 & 2. 11th edition. CBS Publishers(2016).

Course Books published in Hindi may be prescribed by the Universities and Colleges

Course prerequisites: To study this course, a student must have had the subject biology in class/12th

Suggested Continuous Evaluation Methods:

Total Marks: 25

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class performance/Participation: 5 Marks

Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Programme/Class: Diploma	Year: Second	Semester: Fourth
Subject: ZOOLOGY		
Course Code: B050402P	Course Title: Lab on Chordates, Biochemistry and Physiology	

Course outcomes:

The student at the completion of the course will be able to:

- Understand and appreciate chordate diversity
- Understand the structure of biomolecules like proteins, lipids and carbohydrates
- Perform basic hematological laboratory testing,
- Distinguish normal and abnormal hematological laboratory findings to predict the diagnosis of hematological disorders and diseases.

Credits: 2	Core: Compulsory
Max. Marks: 25+75	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P:0-0-4

Unit	Topics	Total No. of Practical Hours (60)
I	Study of Representative specimens/models of various classes of vertebrates- Petromyzon, Myxine, Scoliodon, Labeo, Wallago, Mystus, Channa, Exocoetes, Frog, Toad, Ichthyophis, Rhacophorus, Alytes, Turtle, Hemidactylus, Varanus, Naja, Bungarus, Viper, Models of Crocodylus, Gavialis, Alligator, Archaeopteryx, Brontosaurus. stuffed bird specimens- Eudynamis, Passer domesticus, duck, Owl, kite, vulture, Parrot, Peacock, Bulbul; Models of Echidna, Platypus, Macropus, Opposum, Hystrix, Rabbit and mole.	15
II	1. To prepare stained/unstained slide of placoid, cycloid and ctenoid scales. 2. Comparative study of bones of amphibians and mammals. 3. Comparative study of histological slides of different tissues of vertebrates. 4. Study of common edible fishes of Uttar Pradesh. 5. Dissection and fag labeling of afferent and efferent branchial vessels and cranial nerves in Wallago/ Labeo	10
III	1. Estimation of haemoglobin using Sahli's haemoglobinometer 2. Preparation of haemin and haemochromogen crystals 3. To study different mammalian blood cell types using Leishman stain. 4. Recording of blood pressure using a sphygmomanometer 5. Recording of blood glucose level by using glucometer	10
IV	1. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid 2. Recording of simple muscle twitch with electrical stimulation (or Virtual) 3. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)	10

V	1. Ninhydrin test for α-amino acids. 2. Benedict's test for reducing sugar and iodine test for starch. 3. Test for sugar and acetone in urine. 4. Qualitative tests of functional groups in carbohydrates, proteins and lipids. 5. Action of salivary amylase under optimum conditions.	10
VI	**Virtual Labs (Suggestive sites)** 1. https://www.vlab.co.in 2. https://zoologysan.blogspot.com 3. www.vlab.iitb.ac.in/vlab 4. www.onlinelabs.in 5. www.powershow.com 6. https://vlab.amrita.edu 7. https://sites.dartmouth.edu	5

Suggested Readings:

1. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
4. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
5. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition.Lippincott W. & Wilkins.
6. Arey, L.B. (1974). Human Histology. IV Edition. W.B. Saunders.
7. Kesar, Saroj and Vashishta N. (2007). Experimental Physiology: Comprehensive Manual. Heritage Publishers, New Delhi

Course Books published in Hindi may be prescribed by the Universities and Colleges

Course prerequisites: To study this course, a student must have had the subject biology in class/12th The eligibility for this paper is 10+2 from Arts/ Commerce/ Science

Suggested Continuous Evaluation Methods:

Total Marks: 25

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class performance/Participation: 5 Marks

Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: University must ensure incorporation of all 06 units including virtual labs in practical evaluation.

Proramme/Class: Degree	Year: Third	Semester: Fifth
Subject: ZOOLOGY		
Course Code: B050501T	**Course Title:** Evolutionary and Developmental Biology	

Course outcomes:

The student at the completion of the course will be able to:

- Understand that by biological evolution we mean that many of the organisms that inhabit the earth today are different from those that inhabited it in the past.
- Understand that natural selection is one of several processes that can bring about evolution, although it can also promote stability rather than change.
- Understand how the single cell formed at fertilization forms an embryo and then a full adult organism.
- Integrate genetics, molecular biology, biochemistry, cell biology, anatomy and physiology during embryonic development.
- Understand a variety of interacting processes, which generate an organism's heterogeneous shapes, size, and structural features.
- Understand how a cell behaves in response to an autonomous determinant or an external signal, and the scientific reasoning exhibited in experimental life science.

Credits: 5	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:** 4-0-0

Unit	Topic	Total No. of Lectures (75)
I	**Theories of Evolution** • Origin of Life • Historical review of evolutionary concept: Lamarckism, Darwinism (Natural, Sexual and Artifical selection) • Modern synthetic theory of evolution • Patterns of evolution (Divergence, Convergence, Parallel, Coevolution)	15
II	**Population Genetics** • Microevolution and Macroevolution: allele frequencies, genotype frequencies, Hardy-Weinberg equilibrium and conditions for its maintenance • Forces of evolution: mutation, selection, genetic drift	8
III	**Direct Evidences of Evolution** Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse	8

IV	**Species Concept and Extinction** • Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric)	7
	• Mass extinction (Causes, Names of five major extinctions	
V	**Gametes, Fertilization and Early Development** • Gametogenesis • Fertilization • Cleavage • Gastrulation, • Fate maps • Developmental mechanics of cell specification	15
VI	**Developmental Genes** • Genes and development • Differential gene expression • Environmental regulation of development	7
VII	**Early Vertebrate Development** • Fish • Birds • mammals	7
VIII	**Late Developmental Processes** • Development of eye, limb in vertebrate • Metamorphosis: the hormonal reactivation of development in amphibians, insects • Regeneration: salamander limbs, mammalian liver, Hydras • Aging: the biology of senescence	8

Suggested Readings:

1. Ridley, M. (2004). *Evolution*. III Edition. Blackwell Publishing
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). *Evolution*. Cold Spring, Harbour Laboratory Press.
3. Hall, B. K. and Hallgrimsson, B. (2008). *Evolution*. IV Edition. Jones and Bartlett Publishers
4. Campbell, N. A. and Reece J. B. (2011). *Biology*. IX Edition, Pearson, Benjamin, Cummings.
5. Douglas, J. Futuyma (1997). *Evolutionary Biology*. Sinauer Associates.
6. Developmental Biology: T. Subramaniam, (Reprint), Narosa Publishing House Pvt. Ltd., New Delhi (2013).
7. Essential Developmental Biology: Jonathan M. W. Slack, (3rd ed.), Wiley-Blackwell. (2012).
8. Developmental Biology: From a Cell to an Organism (Genetics & Evolution) eBook: Russ Hodge, Infobase Publishing. (2009).
9. Current Topics in Developmental Biology: Roger A. Pedersen, Gerald P. Schatten, Elsevier. (1998).
10. Developmental biology: Werner A. Müller, Springer Science & Business Media. (2012).
11. Human Embryology and Developmental Biology E-Book: Bruce M. Carlson, Elsevier Health Sciences. (2018).
12. Developmental Biology: Michael J. F. Barresi, Scott F. Gilbert, Oxford University Press. (2019).
13. Balinski A I: Embryology

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects:The eligibility for this paper is 10+2 with Biology as one of the subject

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class performance/Participation:5 Marks

Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Programme/Class: Degree	Year: Third	Semester: Fifth
Subject: ZOOLOGY		
Course Code: B050502T	Course Title: Ecology, Ethology and Wildlife	

Course outcomes:

The student at the completion of the course will learn:

- Complexities and interconnectedness of various environmental levels anc their functioning.
- Global environmental issues, their causes, consequences and amelioration.
- To understand and identify behaviours in a variety of taxa.
- The proximate and ultimate causes of various behaviours.
- About the molecules, cells, and systems of biological timing systems.
- Conceptualizing how species profitably inhabit in the temporal environment and space out their activities at different times of the day and seasons.
- To interpret the cause and effect of lifestyle disorders contributing to public understanding of biological timing.
- To understand the importance of wildlife conservation.

Credits: 5	Core: Compulsory
Max. Marks: 25+75	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:** 4-0-0

Unit	Topic	Total No. of Lectures (75)
I	**Introduction to Ecology** • History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of physical factors	7
II	**Concept of Ecosystem** • Structure and function of ecosystem, Types of ecosystems with one example, Food chain: Detritus and grazing food chains, Food web; Energy flow through the ecosystem • Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example of Carbon cycle	12
III	**Population and Community Ecology** • Population characteristics: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion	15

	,Exponential and logistic growth, • Community characteristics: species richness, dominance, diversity, abundance, Ecological succession with one example	

IV	**Environmental Hazards** • Sources of Environmental hazards • Climate changes • Greenhouse gases and global warming • Acid rain, Ozone layer destruction	7
V	**Effects of Climate Change** • Effect of climate change on public health • Sources of waste, types and characteristics, Sewage disposal and its management, Solid waste disposal, Biomedical waste handling and disposal, • Nuclear waste handling and disposal, Waste from thermal power plants, • Case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath.	7
VI	**Behavioural Ecology and Chronobiology** • Origin and history of Ethology, • Instinct vs. Learnt Behaviour • Associative learning, classical and operant conditioning, Habituation, Imprinting, • Circadian rhythms; Tidal rhythms and Lunar rhythms • Chronomedicine	10
VII	**Introduction to Wild Life** • Values of wild life - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies. • Prominent wildlife of India: Birds and Mammals	10
VIII	**Protected areas** • National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve	7

Suggested Readings:

1. Ecology: Theories & Applications. Peter D. Stiling, 2001, Prentice Hall.
2. Ecological Modeling. 2008. Grant, W.E. and Swannack, T.M., Blackwell.
3. Ecology: The Experimental Analysis of Distribution and Abundance. Charles J. Krebs, 2016, Pearson Education Inc.
4. Elements of Ecology. T.M. Smith and R.L. Smith, 2014, Pearson Education Inc.
5. Environmental Chemistry. 2010. Stanley and Manahan, E. CRC, Taylor & Francis. London.
6. Environment. Raven, Berg, Johnson, 1993, Saunders College Publishing.
7. Essentials of Ecology. G.T. Miller, Jr. & Scott. E. Spoolman, 2014, Brooks/Cole, Cengage Learning.
8. Freshwater Ecology: A Scientific Introduction. 2004. Closs, G., Downes, B. and Boulton, A. Wiley-Blackwell publisher, Oxford.
9. Fundamental Processes in Ecology: An Earth system Approach. 2007. Wilkinson, D.M. Oxford University Press, UK.
10. Fundamentals of Ecology. E.P. Odum& Gray. W. Barrett, 1971, Saunders
11. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
12. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.
13. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5 th edition. The Wildlife Society, Allen Press.
14. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
15. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects:

The eligibility for this paper is 10+2 with Biology as one of the subject

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class Performance/Participation: 5 Marks

Further Suggestions: None

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At the End of the whole syllabus any remarks/ suggestions: None

Programme/Class: Degree	Year: Third	Semester: Sixth
Subject: ZOOLOGY		
Course Code: B050601T	Course Title: Molecular biology, Bioinstrumentation & Biotechniques	

Course outcomes:

The student at the completion of the course will be able to have:

- A detailed and conceptual understanding of molecular processes *viz.* DNA to trait.
- A clear understanding of the processes of central dogma *viz.* transcription, translation *etc.* underlying survival and propagation of life at molecular level.
- Understanding of how genes are ultimately expressed as proteins which are responsible for the structure and function of all organisms.
- Learn how four sequences (3 letter codons) generate the transcripts of life and determine the phenotypes of organisms.
- How genes are regulated differently at different time and place in prokaryotes and eukaryotes.

Credits: 4	Core: Compulsory
Max. Marks: 25+75	Min. Passing Marks: as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P:4-0-0

Unit	Topic	Total No. of Lectures (60)
I	**Process of Transcription** • Fine structure of gene • RNA polymerases • Transcription factors and machinery • Formation of initiation complex • Initiation, elongation and termination of transcription in prokaryotes and eukaryotes	7
II	**Process of Translation** • The Genetic code • Ribosome • Factors involved in translation • Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase • Initiation, elongation and termination of translation in prokaryotes and eukaryotes	7
III	**Regulation of Gene Expression I** • Regulation of gene expression in prokaryotes: *lac* and *Trp* operons in *E. coli* • Regulation of gene expression in eukaryotes: Role of chromatin in gene expression • Regulation at transcriptional level and Post-transcriptional	8

	modifications: Capping, Splicing, Polyadenylation • RNA editing.	
IV	**Regulation of Gene Expression II** • Regulation of gene expression in eukaryotes: • Regulation at translational level, Post- translational modifications: protein folding etc. • Intracellular protein degradation • Gene silencing, RNA interference (RNAi)	8
V	**Principle and Types of Microscopes** • Principle of Microscopy and Applications • Types of Microscopes: light microscopy, dark field microscopy, phase-contrast microscopy, • Fluorescence microscopy, confocal microscopy, electron microscopy	6
VI	**Centrifugation and Chromatography** • Principle of Centrifugation • Types of Centrifuges: high speed and ultracentrifuge • Types of rotors: Vertical, Swing-out, Fixed-angle etc. • Principle and Types of Chromatography: paper, ion-exchange, gel filtration, HPLC, affinity	8
VII	**Spectrophotometry and Biochemical Techniques** • Biochemical techniques: Measurement of pH, Preparation of buffers and solutions • Principle of Colorimetry/Spectrophotometry: Beer-Lambert law • Measurement, applications and safety measures of radio-tracer techniques	8
VIII	**Molecular Techniques** • Detection of nucleic acid by gel electrophoresis • DNA sequencing, DNA fingerprinting, RFLP • Polymerase Chain Reaction (PCR) • Detection of proteins, PAGE, ELISA, Western blotting	8

Suggested Readings:

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
2. Alberts et al: Molecular Biology of the Cell: Garland (2002).
3. Cooper: Cell: A Molecular Approach: ASM Press (2000).
4. Karp: Cell and Molecular Biology: Wiley (2002).
5. Watson et al. Molecular Biology of the Gene. Pearson (2004).
6. Lewin. Genes VIII. Pearson (2004).
7. Pierce B. Genetics. Freeman (2004).
8. Sambrook*et al* .Molecular Cloning Vols I, II, III. CSHL (2001).
9. Primrose. Molecular Biotechnology. Panima (2001).
10. Clark & Switzer. Experimental Biochemistry. Freeman (2000)

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects: The eligibility for this paper is 10+2 with Biology as one of the subject
Suggested Continuous Evaluation Methods: **House Examination/Test**: 10 Marks **Written Assignment/Presentation/Project / Term Papers/Seminar**: 10 Marks **Class performance/Participation:** 5 Marks
Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Programme/Class: Degree	**Year:** Third	**Semester:** Sixth
Subject: ZOOLOGY		
Course Code: B050602T	**Course Title:** Gene Technology, Immunology and Computational Biology	

Course outcomes:

The student at the completion of the course will be able to:

- Understand the principles of genetic engineering, how genes can be cloned in bacteria and the various technologies involved in it.
- Know the applications of biotechnology in various fields like agriculture, industry and human health.
- To have an in depth understanding about Immune System & its mechanisms.
- Get introduced to DNA testing and utility of genetic engineering in forensic sciences.
- Get introduced to computers and use of bioinformatics tools.
- **Enable students to get employment in pathology/Hospital.**
- **Take up research in biological sciences.**

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:** 4-0-0

Unit	Topic	Total No. of Lectures (60)
I	**Principles of Gene Manipulation** • Recombinant DNA Technology • Selection and identification of recombinant cells • Restriction Enzymes, DNA modifying enzymes, Cloning Vectors, Ligation • Gene transfer techniques, Gene therapy	12
II	**Applications of Genetic Engineering** • Single cell proteins • Biosensors, Biochips • Crop and livestock improvement, development of transgenics • Development of DNA drugs and vaccines	10
III	**Immune System and its Components** • Historical perspective of Immunology, Innate and Adaptive Immunity, clonal selection, complement system • Structure and functions of different classes of immunoglobulins, Hypersensitivity • Humoral immunity and cell mediated immunity	10
IV	**Biostatistics I** • Calculations of mean, median, mode, variance, standard deviation • Concepts of coefficient of variation, Skewness, Kurtosis • Elementary idea of probability and application	7

V	**Biostatistics II** • Data summarizing: frequency distribution, graphical presentation pie diagram, histogram • Tests of significance: one and two tailed tests, t-test and Chi-square test	7
VI	**Basics of Computers** • Basics (CPU, I/O units) and operating systems • Concept of homepages and websites, World Wide Web, URLs, using search engines	6
VII	**Bioinformatics** • Databases: nucleic acids, genomes, protein sequences and structures, Bibliography • Sequence analysis (homology): pairwise and multiple sequence alignments-BLAST, CLUSTALW • Phylogenetic analysis	8

Suggested Readings:

1. Primrose &Twyman. Principles of Genome Analysis and Genomics. Blackwell (2003).
2. Hartl& Jones. Genetics: principles &Analsysis of Genes & Genomes. Jones & Bartlett (1998).
3. S6mbrook *et al* .Molecular Cloning Vols I, II, III. CSHL (2001).
4. Primrose. Molecular Biotechnology. Panima (2001).
5. Clark & Switzer. Experimental Biochemistry. Freeman (2000)
6. Sudbery. Human Molecular Genetics. Prentice-Hall (2002).
7. Wilson. Clinical Genetics-A Short Course, Wiley (2000).
8. Pasternak. An Introduction to Molecular Human Genetics. Fritzgerald (2000).
9. Biostatistical Analysis (Fourth Edition) by Jerrold H. Zarr, Pearson Education Inc., Delhi.
10. Statistical Methods (Eighth Edition) by G. W. Snecdecor and W. G. Cochran, Willey Blackwell
11. Biostatistics (Tenth Edition) by W.W. Daniel and C. L. Cross, Wiley
12. Introductory Biological Statistics (Fourth Edition) by John E. Havel, Raymond E. Hampton and Scott J. Meiners
13. Westhead*et al* Bioinformatics: Instant Notes. Viva Books (2003).

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects:

The eligibility for this paper is 10+2 with Biology as one of the subject.

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class performance/Participation: 5 Marks

Further Suggestions: None

Programme/Class: Degree	Year: Third	Semester: Sixth
Subject: ZOOLOGY		
Course Code: B050602P	**Course Title:** Lab on Ecology, Embryology, Biotechniques and Computational Biology	

Course outcomes:

The student at the completion of the course will be able to:

- Understand the basic concepts, importance, status and interaction between organisms and environment and appreciate the value of wildlife in the ecosystem.
- Develop knowledge about animal development.
- Get knowledge about techniques used in modern research etc.
- Enable students to use principles of biostatistics and bioinformatics for analysis of data.

Credits: 2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:** 0-0-4

Unit	Topic	Total No. of Practical Hours (60)
I	Study of an aquatic ecosystem, its biotic components and food chain. › Estimation of Dissolved oxygen and carbon dioxide in given water sample. › Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided. › Study of population dynamics through numerical problems. › Study of circadian functions in humans (daily eating, sleep and temperature patterns).	15
II	1. To study working principle of simple and compound microscope. 2. To study working principles of lab equipments- pH meter, Centrifuge, Spectrophotometer and PCR. 3. To identify amino acids using Paper chromatography 4. Determination of ABO blood group 5. Demonstration of DNA extraction from blood or tissue sample 6. Demonstration of agarose gel electrophoresis for detection of DNA, and PAGE for detection of Proteins 7. To study Restriction enzyme digestion using teaching kits. 8. To detect genetic mutations by Polymerase Chain Reaction (PCR) using teaching kits.	15

III	To measure the pre and post clitellar lengths of earthworm and to calculate Mean, Median, mode and standard deviation. To learn presentation of data in the form of frequency table and graph. To learn sequence analysis using BLAST To learn multiple sequence alignment using CLUSTALW To learn about phylogenetic analysis using the programme Phylip	15
IV	Study of common insect pests of stored grain and crop Study of mouth parts of cockroach Study of embryonic stages of frog and chick through permanent slides Report on a visit to National Park/Biodiversity Park/Wild life sanctuary	10
IV	**Virtual Labs (Suggestive sites)** 1. Gel Documentation System- https://youtu.be/WPpt3-FanNE 2. Colorimeter- https://youtu.be/v4aK6G0bGuU 3. PCR Part 1- https://youtu.be/CpGX1UFSl4A 4. PCR Part 2- https://youtu.be/6IcHAYPTAEw 5. DNA isolation Part 1- https://youtu.be/QE7Ul0JnY9A 6. DNA isolation part 2- https://youtu.be/-efr_HFeHxM 7. DNA curve- https://youtu.be/ubL8QxTeuG4 8. Spectrophotometer- https://youtu.be/ubL8QxTeuG4 9. Agarose Part 1- https://youtu.be/7gvHPFww--g 10. Agarose part 2- https://youtu.be/j_bOZCHNsSg 11. Use softwares like Primer3, NEB cutter NCBI, BLAST, CLUSTAL W, PHYLIP 12. https://www.vlab.co.in 13.	5

	13. https://zoologysan.blogspot.com 14. 14. www.vlab.iitb.ac.in/vlab	

Suggested Readings:

1. Ecology: The Experimental Analysis of Distribution and Abundance. Charles J. Krebs, 2016, Pearson Education Inc.
2. Fundamentals of Ecology. E.P. Odum& Gray. W. Barrett, 1971, Saunders.
3. Robert Leo Smith Ecology and field biology Harper and Row publisher
4. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5th edition. The Wildlife Society, Allen Press.
5. Methods and Practice in biodiversity Conservation by David Hawks worth, Springer publication.

Course Books published in Hindi may be prescribed by the Universities and Colleges

This course can be opted as an elective by the students of following subjects:

The eligibility for this paper is 10+2 from Arts/Commerce/Science

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 Marks

Written Assignment/Presentation/Project / Term Papers/Seminar: 10 Marks

Class performance/Participation: 5 Marks

Further Suggestions: None

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At the end of the whole syllabus any remarks/ suggestions: University must ensure incorporation of all 04 units including virtual labs in practical evaluation.

STRUCTURE OF THE SYLLABUS FOR B. Sc. Fourth Year and M. Sc. In ZOOLOGY

EFFECTIVE FROM SESSION: 2025-26

Course Code	Course Type	Course Title	Course Credit	T/P	Evaluation	
					CIE	ETE
A	B	C	D	E	F	G
B. Sc. Semester VII (Fourth Year) / M. Sc. Semester I (First Year)						
	Core	Non-Chordata: General Account	4	T	25	75
	Core	Biochemistry	4	T	25	75
	Core	Principles of Ecology and Wildlife	4	T	25	75
	Elective I (Select any one)	1. Toxicology	4	T	25	75
		2. Ethology	4	T	25	75
	Elective II (Select any one)	1.Practical based on core and First elective	4	P	25	75
		2. Practical based on core and Second elective	4	P	25	75
B. Sc. Semester VII (Fourth Year)/M. Sc. Semester II (First Year)						
	Core	Chordata: General Account	4	T	25	75
	Core	Systematics and Evolution	4	T	25	75
	Core	Animal Physiology	4	T	25	75
	Elective I (Select any one)	Immunology	4	T	25	75
		Endocrinology	4	T	25	75
	Elective II (Select any one)	1.Practical based on core and First elective	4	P	25	75
		2. Practical based on core and Second elective	4	P	25	75
M. Sc. Semester III (Second Year)						
	Core	Histology and	4	T	25	75

		Histochemistry				
	Core	Developmental Biology	4	T	25	75
	Elective I (Select any one)	1.Morphology, Physiology and Development of Fishes	4	T	25	75
		2. Taxonomy, Morphology and Physiology of Insects	4	T	25	75
	Elective II (Select any one)	1. Practical based on core and First Elective	4	P	25	75
		2. Practical based on core and Second elective	4	P	25	75
	Research Project	Research Project/Dissertation	4	P	50	50
M. Sc. Semester IV (Second Year)						
	Core	Genetics and Molecular Biology	4	T	25	75
	Core	Biological Tools and Techniques	4	T	25	75
	Core	Biostatistics and Bioinformatics	4	T	25	75
	Elective I (Select any one)	1.Applied Ichthyology	4	T	25	75
		2.Applied Entomology	4	T	25	75
	Research Project	Major Research Project/ Dissertation	4	P	50	50

Note: Explanation for Terms used in Columns

1. Column - A to be filled by the University.
2. Column -B defines nature of course/paper. The term 'Core' herein stands for compulsory subject paper. Term 'Elective' refers to a course which is chosen by the student from the two options.
3. Column - C describes the title of the course/ paper.
4. Column- D depicts credits for corresponding course/paper.
5. Column -E, T/P stands for Theory/Practical.
6. Column -F, CIE stands for continuous internal evaluation and depicts the

maximum internal marks for the course/paper. Exam to be conducted by the subject teacher/ college.

7. Column – G, ETE stands for the end term evaluation or external evaluation and depicts the maximum external marks for the course/paper. ETE to be conducted by the university.
8. First elective: In each semester it will be a subject elective. Students may select one of the two subject papers under this category.
9. Second elective: In all four semesters of the program, it will designate a practical paper/course based on core and elective paper.
10. In Semester III, if a student chooses to study Morphology, Physiology and Development of Fishes, then in Semester IV the student will study Applied Ichthyology. Similarly, if a student chooses to study Taxonomy, Morphology and Physiology of Insects in Semester III, student will have to study Applied Entomology in Semester IV.
11. In Semester III and IV, every student will carry out a research project and submit its report. Research project may involve survey/field visit/practical/industrial training and will be submitted in writing for evaluation.
12. Students who opt for 4-year UG Degree (Honors with Research) should drop third paper in Semester VII and VIII and will conduct one research project in each semester. Thus, they will complete their credits by dropping one paper for one project in each semester.

DETAILED SYLLABUS OF ZOOLOGY

B. Sc. SEMESTER VII/M.Sc. (PREVIOUS) SEMESTER I

PAPER-I NON- CHORDATA: GENERAL ACCOUNT

Unit-1: Pranishastra and Bharatvarsh: Ancient Indian texts on Animals, Traditional Indian practices of animal management, veterinary science and conservation, Cultural depiction of Animals in traditional art and festivals, Contributions of Great scholars of Ancient India- Dhanvantari, Chyavan, Charak, Sushrut, Vagbhatta, Jivak, Pal Kapya, Shalihotra, Surpal, and Varahmihir.

Unit 2: Nutrition and reproduction in Protozoa: Origin of Metazoa, Canal system in Porifera; Polymorphism and Colony formation in Cnidaria; Coral reefs; Parasitic adaptations in Helminths, Larval stages of Trematoda and Cestoda.

Unit 3: Segmental organs in Annelida; Adaptive radiations in Annelida. Organization and affinities of Onychophora; Larval forms in Crustacea; Parasitism in Crustacea; Social life in insects and Mouth parts in insects.

Unit 4: Torsion in gastropods, Larval forms in Echinodermata; Water vascular system in Echinodermata; Affinities of Echinodermata; Brief outlines of the structure and affinities of minor phyla with special reference to Ctenophora, Rotifera, and Phoronida.

Suggested Literature:

1. Advances in invertebrates' reproduction by K.G. Adiyodi and R.G. Adiyodi, Peralam- Kenoth Kerivellur, Kerala.
2. A text book of invertebrates by R L Kotpal, Rastogi Publications, Meerut
3. Invertebrate Zoology by Jordan and Verma, S. Chand Publication New Delhi
4. Invertebrate zoology by Kaestner, Levi & Levi, John Wiley & Sons Inc.
5. Krishi Prasar by Parashara, Asian Agri-History Foundation.
6. Animal husbandry in Ancient India, A T Kumar, R Singh and V Singh, Lambert.
7. Ancient India: R C Majumdar
8. The Invertebrates by L.H. Hymen, McGraw-Hill Book Company.
9. India's contribution to World culture: Sudheer Birodkar
10. Invertebrates Zoology by R.D. Barnes, V Edition. Holt Saunders International edition.

ZOOLOGY

B. Sc. SEMESTER VII / M.Sc. (PREVIOUS) SEMESTER I

PAPER- 2: BIOCHEMISTRY

THEORY

Unit-I: Composition, structure and function of biomolecules (Carbohydrates, lipids, Proteins and Nucleic acids), Structure and function of Hemoglobin; Principles of biophysical chemistry (pH, pK, buffer, Henderson Hasselbalch equation, reaction kinetics and Bioenergetics).

Unit-II: Metabolism: Basic concepts and Design, Glycolysis, Krebs' Cycle, Oxidative phosphorylation, Gluconeogenesis, Glycogen metabolism, Fatty acid metabolism, Protein turnover and Amino acid catabolism, Integration of metabolism.

Unit-III: Catalytic and Regulatory Strategies: Basic concepts of enzymes and enzyme kinetics, Michelis-Menten equation, Mechanism of enzyme action, Enzyme regulation - Allosteric enzymes, isozymes, covalent modification and proteolytic cleavage. Vitamins

Unit-IV: Central Dogma of Information Flow: DNA replication, Transcription and Translation; DNA polymerase and RNA polymerase and Ribosomes.

Suggested Literature:

1. Biochemistry Ninth Ed. by Berg, Tymoczko, Gatto Jr and Stryer, Macmillan
2. Lehninger's Principles of biochemistry by Nelson and Cox W.H. Freeman Company
3. Cell-physiology and Biochemistry by W.D. McElory, Prentice Hall of INDIA Pvt LTD
4. Comparative biochemistry by K.A Munday, Pergmon Press Oxford London
5. Essentials of Biochemistry by Srivastva; Lal; N. Singh, Rekha Publications
6. Essentials of Biological chemistry by Fairley Kil gour, Affiliated east -west Press
7. Harper's Biochemistry by R.K. Murray, D.K Granner, A long medical book.
8. Introduction to biochemistry by J. Awapra, Prentice Hall of INDIA Pvt LTD
9. Fundamentals of Biochemistry by J L Jain et al., S. Chand New Delhi

ZOOLOGY

B. Sc. SEMESTER VII/M.Sc. (PREVIOUS) SEMESTER I

PAPER-III PRINCIPLES OF ECOLOGY AND WILDLIFE:

THEORY

Unit-I: Concept of Ecology and Environment: Abiotic and Biotic factors; Habitat and Niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation.

Unit-II: Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

Unit-III: Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine). Biogeography: Major terrestrial biomes; biogeographical zones of India.

Unit-IV: Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology: Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Suggested literature:

1. Fundamentals of Ecology Fifth Ed. by Eugene P. Odum and Gray W. Barrett, Cengage
2. What is biodiversity by James Maclaurin and Kim Sterelny, U. Chicago.Edu.
3. Biological Systematics: Principles and Applications 2nd Ed. By Schuh and Brower. Cornell University Press.
4. Phylogenetics: Theory and Practice of Phylogenetic Systematics, 2nd Ed. Wiley,
5. Foundations of Systematics and Biodiversity by Williams and Ebach. 2010. Springer.
6. Biodiversity and Ecosystem Functioning by Shulze and Moonthy, Springer Publication.
7. Methods and Practice in biodiversity Conservation by D H worth, Springer publication

ZOOLOGY

B. Sc. SEMESTER VII/M.Sc. (PREVIOUS) SEMESTER I

PAPER IV- ELECTIVE (1) – TOXICOLOGY

THEORY

Unit-1: Toxicology; Introduction, Basic concepts, Types of Toxicants (Heavy metals, Pesticides and Radioactive substances), Exposure of toxicants, Translocation of Toxicants and mechanism of action of Toxicants.

Unit -2: Toxic Action- Acute toxicity, Acute exposure and effect, Dose-Response Relationships, mechanism of acute toxicity- Narcosis, Acetylcholinesterase Inhibition, Ion channel modulators, inhibitors of cellular respiration; chemical carcinogenesis, human carcinogens, mutagenicity assays for identification of carcinogens; Teratogenesis introduction, historical teratogens, critical periods for teratogenesis; Chronic toxicity.

Unit 3: Organ Toxicity- Hepatotoxicity: Types of liver injury- fatty liver, Necrosis, Apoptosis, Cirrhosis, Hepatitis; hepatotoxicants; Nephrotoxicity: Susceptibility of renal system, nephrotoxicants; Respiratory Toxicity-susceptibility of respiratory system, toxic response-Irritation, Cell necrosis, Fibrosis, Emphysema, Endocrine disruptors

Unit-4: Selective Toxicity; Biotransformation, Bioaccumulation and Biomagnification of Xenobiotics; Antidotal Therapy; Toxicity Tests; Biomonitoring of Toxic Chemicals, Bioindicators.

Suggested literature

1. Modern Toxicology - Earnest Hodgson Wiley
2. Toxicology and risk assessment principles. Methods and application by Anna M Fan, Louis W Chang, Marcel Dekker, inc, New York.
3. Concept of Toxicology, Dr. Omkar
4. A Textbook of Modern Toxicology by E. Hodgson Wiley Interscience
5. Casarett & Doull's Essentials of Toxicology -Lange

ZOOLOGY

B. Sc. SEMESTER VII/M.Sc. (PREVIOUS) SEMESTER I

PAPER IV- ELECTIVE (2) – ETHOLOGY

THEORY

Unit I: Introduction and significance of study of Ethology, History and Branches of Ethology, Patterns of behaviour- Instinctive and Learnt, Behavioural Genetics, Evolution of behaviour

Unit II: Communication and animal signals: Introduction, Auditory communication, Infrasound communication in elephants and whales, Ultrasound communication - Echolocation in Bats, Visual communication- postures and gestures, Bee language, Chemical communication- Pheromones of invertebrates and vertebrates, Functions of scent in vertebrates.

Unit-3: Social Behavior in animals: Introduction, Advantages of being social, Types of social behavior, Altruism, Food sharing, Cooperation and Reciprocation, Eusociality, societies of apes and honey bee. Proximate and Ultimate causes of behavior.

Unit-4: Reproductive behavior in animals; Sexual selection, mating patterns, mating strategies in animals, Territorial behavior, Courtship and Mating Behavior of stickleback and peacock, Parental Care in fishes and amphibians, biological clocks.

Suggested Literature:

1. An Introduction to Animal Behaviour by Manning and MS Dawkins Cambridge University Press, UK.
2. Animal Behaviour by John Alcock, Sinauer Association, INC.
3. Animal Behaviour in the Laboratory by P. Silverman, London. Chapman and Hall.
4. Introduction to Animal Behaviour by Rishikesh and Niraj, Campus Bools.
5. Text Book of Animal Behaviour by FB Mann PH learning Pvt Ltd.
6. Animal Behaviour by Reena Mathur, Rastogi Publications, Meerut

ZOOLOGY

B. Sc. SEMESTER VII/M.Sc. SEMESTER I

Semester-I Practical

Time: 6 hours

Exercises	Distribution of Marks:
Dissection	10 Marks
Preparation of Permanent Slide	08 Marks
Biochemistry Exercise	08 Marks
Ecological Exercise	08 Marks
Toxicology/Animal behavior	07 Marks
Spotting (10 spots)	20 Marks
Viva voce	07 Marks
Class records	07 Marks

Total Marks: 100 (25- internal evaluation + 75- external examination)

Museum/ Specimens and Slides of Non – Chordata:

Porifera: Study of museum specimens/models; Lecuosolenia, Sycon, Grantia, Euplectella, Hyalonema, Oscarella, Chondrilla, Cliona, Chalina, Spongilla, Euspongia, Hippospongia.

Cnidaria: Tubularia, Bougainvillia, Pennaria, Hydractinia, Sertularia, Campanularia, Millepora, Stylaster, Physalia, Porpita, Velella, Aurelia, Rhizostoma, Tubipora, Alcyonium, Gorgonia, Corallium, Pennatula, Metridium, Adamsia, Cerianthus, Fungia, Madrepora, Pleurobrachia, Beroe.

Helminths: Convoluta, Dugesia, Bipalium, Fasciola, Paramphistomum, Schistosoma, Taenia, Cysticercus larva, Moniezia, Echinococcus, Trichuris, Trichinella, Heterodera, Enterobius, Ascaris, Ancylostoma, Dracunculus, Wuchereria.

Annelida: Aphrodite, Tomopteris, Glycera, Chaetopterus, Arenicola, Sabella, Amphitrite, Serpula, Tubifex, Branchiobdella, Eisenia, Placobdella, Pontobdella, Branchellion, Polygordius.

Arthropoda: Limulus, Palamnaeus, Lycosa, Apus, Argulus, Balanus, Sacculina, Mysis, Gammarus, Squilla, Prawn, Lobster, True crab, Hermit crab, Julus, Scolopendra, Scutigerella, Lepisma, Mantis, Stick insect, Grass hopper, Cicada, Termites, Forficula, Pediculus, Ranatra, Dysdercus, Musca, Lady bird beetle, Butterfly, Wasp, Xenopsylla, life history of honey bee, lac insect and silk moth; Study of prepared slides:

Mollusca: Chiton, Dentaliun, Pila, Aplysia, Buccinum, Doris, Lymnaea, Mytilus, Patella,

Pecten, Limax, Pearl oyster, Teredo, Nautilus, Loligo, Sepia, Octopus.

Echinodermata: Astropecten, Asterias, Ophiothrix, Echinus, Clypeaster, Thyone, Holothuria, Antedon; Aristotle's lantern. Hemichordata: Study of museum specimens: Balanoglossus, Cephalodiscus: Minor phyla: Representative specimens of Onychophora (Peripatus), Sipunculida (Sipunculus), Echiurida (Bonellia)

Permanent preparation of Paramecium, Ceratium, Noctiluca, Vorticella, Sponge gemmules, sponging fiber and spicules, Obelia and other hydrozoan colonies and Obelia Medusa; Parapodia, Radula of Pila, Gill lamella of Pila, TS Gill lamina of Unio, Statocyst of prawn. To study the different stages of Mitosis in root tip of onion and Meiosis in grasshopper testis.

Study of Permanent Slides: Paramecium Binary fission and Conjugation, Trypanosoma, Vorticella, Noctiluca, Euglena, Sponge Gemmule, Spicules, Obelia colony, Medusa, Scolex of tape worm, mature and gravid proglottid of tape worm; Study of hydatid cyst, larval stages of Fasciola. Parapodium, T.S. of body of leech, Mouth parts of mosquitoes, house fly, honey bee, butterfly, Sarcoptes, Ixodes, Cimex, Daphnia, Cypris, Cyclops, Pediculus, Pthrius, Nauplius, Zoea, Glochidium larva, Bipinnaria, Ohiopluteus, Tornaria larva

Dissection: Nervous system of Pila, Loligo, Palaemon /Squilla

Biochemistry Exercise:

Preparation of model of nucleotide and DNA using wire and beads. Determination of Km Value of an enzyme, Identification of different amino acids in a mixture using paper chromatography, Study of apparatuses/ equipment employed in biochemical analysis – Centrifuge, Spectrophotometer and PCR. Preparation of standard curve using Spectrophotometer, Homogenization and fractionation of cell extract using Centrifuge, Extraction of DNA from any tissue and DNA amplification using PCR, Symptoms of vitamin deficiency

Ecology Exercise:

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO2
4. Study of faunal biodiversity of your campus/locality
5. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

Toxicology and Ethology: Determination of LC50 of a poison for any fish, Study of effect of ammonia and mercury on rat, Study of common pesticides applied in crop fields, Study of common narcotic drugs, Study of Taxis in Housefly, Study of feeding behavior of any insect, study of types of beaks, feet and nests of birds.

ZOOLOGY

B. Sc. SEMESTER VIII/M.Sc. (PREVIOUS) SEMESTER II

PAPER-I CHORDATA: GENERAL ACCOUNT

THEORY

Unit-I: Protochordates and Pisces: Origin of Chordata, General characters and classification of chordates, Affinities of Urochordata and Cephalochordata; General Characters and affinities of Cyclostomes; General characters and classification of fishes; Characteristics and affinities of Dipnoi and Coelocanth.

Unit-II: Amphibia: Origin of Tetrapods, Neoteny and Parental care. Reptilia: Origin and Evolution, Adaptive radiation, Dinosaurs, Crocodilia, Poisonous snakes and their venom. Biting Mechanism.

Unit-III: Aves: Origin, General characters and Classification of Birds, Flightless birds, Adaptations for flight, Migration in Birds.

Unit-IV: Mammalia: Origin, General characters and classification of Mammals, Adaptive radiation in Eutheria, Uterus modifications, Aquatic mammals. Dentition in mammals.

Suggested literature:

1. Harvey et al: The Vertebrate Life (2006)
2. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002, Wiley - Liss)
3. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
4. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill 5. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
6. Parker and Haswell: Text Book of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)
9. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

ZOOLOGY

B. Sc. SEMESTER VIII/M.Sc. (PREVIOUS) SEMESTER II

PAPER II- SYSTEMATICS AND EVOLUTION:

THEORY

Unit-I: Historical aspects of systematics; Trends in biosystematics: concepts of different conventional and newer approaches – chemotaxonomy, cytotaxonomy, molecular taxonomy, numerical taxonomy.

Unit-II: Dimensions of speciation and taxonomic characters: Species concepts, species category, subspecies and infraspecific categories, hierarchy of categories, taxonomic and non-taxonomic characters. Concept of lineage: Types and production of additional lineage; Procedures in taxonomy: collection, preservation and identification; Taxonomic keys- their merits and demerits, systematic publications. International code of zoological nomenclature (ICZN) –its operative principles.

Unit III: Basic concept of organic evolution, Evidences of Evolution, Theories of Evolution-Lamarckism and Darwinism, Neo Lamarckism and Neo Darwinism, Post –Darwinian concepts of evolution: Gradualistic vs. Non-gradualistic theories, Mayr's Founder Principle, Gould's punctuated equilibrium theory, Kimura's neutral theory; Adaptation and Speciation.

Unit-IV: Evolution of populations, Genes in population; Mechanisms causing populations to evolve, Hardy Weinberg Law and Sewall Wright effect, Modern synthetic theory of evolution. Micro evolution and Macro evolution, Evolution of Horse, Evolution of Man, Evolutionary Trees.

Suggested Literature:

1. Mielli A: Biology Systematics, Chapmon and Hall
2. Ridley M: Evolution, Blackwell science
3. Brigss et al: Evolution, cold spring Harbor Laboratory press New York, U.S.A.
4. Futuyama DJ: Evolution Sinauer associates inc. USA
5. Kapoor V C: Animal Taxonomy and Biodiversity, 8th Ed., Oxford and IBH Publishing
6. Freeman and Herron: Evolution, Person /prentice hall
7. Mayer et al: Methods and principle of systematic Zoology, McGraw – Hill
8. Felsentein J: Numerical Taxonomy Springer – Verlag Berlin Heidelberg New York
9. Schenk and Masters: Procedure in Taxonomy Standford University Press.
10. Rastogi V B: Organic evolution 15th Ed Medtech Science Press

ZOOLOGY

B. Sc. SEMESTER VIII/M.Sc. (PREVIOUS) SEMESTER II

PAPER III - ANIMAL PHYSIOLOGY:

THEORY

Unit-1: Physiology of Digestion and Absorption of Proteins, Carbohydrates, Lipids and Nucleic Acids; Secretion and regulation of various digestive juices. Physiology of Respiration; mechanism and regulation of breathing, gaseous exchange in terrestrial and aquatic animals, Oxygen and Carbon dioxide transport, factors affecting oxygen dissociation and respiratory pigments.

Unit-2: Excretion; Urine formation (Glomerular filtration, Tubular reabsorption and Secretion, Counter current mechanism and Hormonal regulation), Acid-base balance and Homeostasis, Circulation; Blood- Composition, Blood Group and Coagulation; Heart- Structure, Origin and Conduction of heart beat and its regulation, cardiac cycle.

Unit-3: Muscles; Types, ultrastructure, chemistry and molecular mechanism of striated muscle contraction and its regulation. Nervous System- Structure of Neuron and Neuroglial cells, mechanism of conduction and transmission of nerve impulse, Synapse and synaptic transmission.

Unit-4: Thermoregulation; Thermoregulation based animal categories, mechanism of thermoregulation and thermal acclimatization, Physiology of sense organs; Eyes and Ears.

Suggested Literature:

1. Animal Physiology by M. Brown, Apple Academic Press.
2. Animal Physiology by R.C. Sobte, Narosa Publishing House.
3. Animal Physiology by F.R. Haninsworth
4. Comparative Animal Physiology by C.L. Prosser, W.B. Saunders Company.
5. Comparative Physiology of Animal by R. W. Hill; P.D. Sturke.
6. Environmental Physiology of Animals by P. Willmer; G. Stone, Blackwell Science Ltd.
7. General and Comparative Physiology by W.S. Hoar, Prentice Hall of India Pvt. Ltd.
8. Marshall's Physiology of Reproduction by G.E. Lamming, Churchill Livingstone.
9. Neural and Integrative Animal Physiology by C.L. Prosser, Wiley India Pvt. Ltd.
10. Principles of Animal Physiology by J.A. Wilson.

ZOOLOGY

B. Sc. SEMESTER VIII/M.Sc. (PREVIOUS) SEMESTER II

PAPERR IV- ELECTIVE (I): PRINCIPLES OF ENDOCRINOLOGY:

THEORY

Unit-I: Introduction and evolutionary perspective of Endocrinology, Hypothalamus, structure and function, Brain nuclei SON, PVN, POA, Arcuate nucleus. Pituitary gland, structure and function (adenohypophysis, Neurohypophysis, pars intermedia), Hypo and Hyperfunction of Pituitary gland; Thyroid gland, Structure and Function, Biosynthesis of Thyroid hormones, Mechanism of action of Thyroid hormones, Hypo and Hyperfunction of Thyroid; Pancreas: Insulin, glucagon and other secretions.

Unit-II: Endocrine regulatory molecules, Chemical classification of hormones, Hormone receptors, Mechanism of hormone action, Neurotransmitters and neuropeptides, Regulatory pathways. Chemical regulation of feeding and digestion.

Unit-III: Neuroendocrine integration; Hypothalamo–hypophysial axis, Feedback mechanisms, Adrenal gland-cellular organization, Catecholamines and General Adaptation Syndrome.

Unit-IV: Endocrine regulation of homeostasis; Hormones and Homeostasis, Electrolytes and water balance (Renin-Angiotensin system), Energy homeostasis, Parathyroid gland, Calcium homeostasis, Endocrine regulation of bone morphogenesis. Hormones of Adrenal cortex.

Suggested literature:

1. Vertebrate Endocrinology: David O. Norris, James A. Carr, 2013, 5th Edition, Academic Press
2. General Endocrinology by Turner C. D., Affiliated East West Press, New Delhi
3. Comparative Vertrebrate Endocrinology: P. J. Bentley, 3rd Edition, Cambridge University Press
4. Neuroendocrinology: Charles B. Nemeroff, CRC, US
5. An Introduction to Neuroendocrinology: Richard E. Brown, 2005, Cambridge University Press
6. Endocrinology: Mac E. Hadley, Jon E. Levine, 2009, 6th Edition, Pearson Education
7. Molecular Endocrinology: F. F. Bolander, 3rd Edition, 2004, Elsevier Academic Press
8. Essential Endocrinology: Darville Brook, C.G. & Marshall, Wiley Blackwell
9. Endocrinology at a Glance: Greenstein B, Wiley Blackwell
10. General and Comparative Endocrinology: John B. Allard, Cunming Duan, Intelliz Press LLC (2016)

ZOOLOGY

B. Sc. SEMESTER VIII/M.Sc. (PREVIOUS) SEMESTER II

PAPER IV- ELECTIVE (2)- IMMUNOLOGY:

THEORY

Unit-I: Types of Immunity (Innate, Adaptive, humoral, cell-mediated), Cells of Immune system (B & T lymphocytes, Phagocytes, Granulocytic cells, Mast cells, NK Cells, Dendritic cells), Organs of Immune system- (Primary and secondary lymphoid organs- Thymus, Bone marrow, lymph nodes, spleen, MAST), Generation of B &T cell responses.

Unit-II: Immunoglobulins (structure, Types/Classes & functions) Epitopes, Maturation differentiation and activation of BCR and TCR. Monoclonal and polyclonal antibodies. Antibody diversity Organization & Expression of Immunoglobulin genes.

Unit-III: Antigen antibody interactions (Agglutination Reactions, Precipitation Reactions, cross reactivity, Antibody affinity and avidity, Immunofluorescence, flow cytometry, Western blotting, Immunoelectron microscopy, RIA, ELISA and it's types.

Unit-IV: Antigen: types, processing & presentation, Major Histocompatibility complex: classes, structure, expression, immune responsiveness, and disease susceptibility (HLA) Complement system–classical, alternative, lectin pathways, Vaccine.

Suggested literature:

1. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (2007) Kuby Immunology. W H Freeman
2. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. (2017). Roitt's Essential Immunology, 13th Edition. Wiley Blackwell
3. Ian. R. Tizard: Immunology, Saunders college Publishing Chicago, New York.
4. Nandini Shetty (2005) Immunology Introductory Textbook. New Age International.
5. Carlberg and Velleur: Molecular Immunology, Springer International Publishing

ZOOLOGY

B. Sc. SEMESTER VIII/M.Sc. SEMESTER II

Practical: Time: 6 hours

Exercises	Distribution of Marks:
Dissection	15 marks
Systematics and Evolution	05 marks
Physiology exercise	10 marks
Immunology/ Endocrinology	10 marks
Spotting (10 spots)	20 marks
Viva voce	7 marks
Class records	8 Marks

Total Marks: 100 (25 - internal evaluation + 75- external examination)

Museum / Specimens of Chordata:

Protochordata: Urochordata: Study of museum specimens/whole mount: Oikopleura, Herdmania, Ascidia, Pyrosoma, Doliolum, Salpa.

Cephalochordata: Branchiostoma

Cyclostomata: Study of museum specimens /models: Petromyzon, Myxine; Ammocoete larva.

Pisces: Study of museum specimens/ models: Sphyrna (hammer – headed shark), Trygon, (string –rays), Pristis , Raja (skate), Torpedo (electric –rays), Chimaera, Polypterus, Acipenser, Polydon , Amia, Lepidosteus, Hilsa, Harppodon , Notopterus, Labeo, Catla, Cyprinus, Cirrhina, Heteropneustes, Clarias, Wallago, Mystus, Anguilla, Exocoteus, Hippocampus, Channa, Amphipnous, Anabas, Synaptura, Echeneis, Neoceratodus, Protopterus, Lepidosiren; Study of disarticulated bone of carp.

Amphibia: Study of museum specimen /models: Ichthyophis, Uraeotyphlus, Cryptobranchus, Ambystoma, Axolotl, larva, Salamandra, Amphiuma, Triturus, Proteus, Necturus, Siren, Alyles, Bufo, Hyla, Rhacophorus, study of disarticulated bone of frog.

Reptilia: Study of museum specimen/models chelone, Sphenodon, Hemidactylus, Calotes, Draco, Phrynosoma, lguana, Heloderma, Varanus, Ophisarus, Typhlops, Python, Natrix, Ptyas, Dendrophis, Bungarus, Naja, Russelle's viper, Pit viper, Hydrophis, Crotalus, Crocodilus, Alligator, Gavialis, Ichthyosarus, Dimentron, Brontosarus, Tyranosarus, Stegosarus, study of disarticulated bones of Varanus

Aves: Study of museum specimens /models: Archaeopteryx, Milvus (kite), Gyps (vulture). Pavo(peacock), Columba (pigeon), Eudynamys (koel), Psittacula (parrot), Bubo (owl), Coracias (nilkanth), Dinopium (Woodpecker), House sparrow, Corvus (crow); study of disarticulated bones of fowl.

Mammals: study of museum specimens / models: Echidna, Ornithorhynchus, Macropus, Erinaceus, Shrew, Pteropus, Bat, Loris, Manis, Hystrix, Funambulus, Rattus, Oryctolagus, Lepus, Herpestes, Lutra, (otter), Civet cat, Macaca, study of disarticulated bones of Rabbit.

Physiology Exercises: Bleeding and clotting time, Preparation of Haemin crystals, Determination of Haemoglobin percentage, Total count of Leucocytes, Erythrocytes, Differential Leucocyte Count, Blood group determination.

Systematics and Evolution: Zoological names of animals, study of fossils and models of extinct animals, study of Geological time scale through charts, Calculation of gene and genotype frequencies

Dissection: General Anatomy and cranial nerves of Labeo/Wallago and

General anatomy and Neck nerves of Rat, Oral hood and Velum of Branchiostma (Ex situ)

Second Semester ELECTIVE (1)-: Immunology lab: Examination of Peripheral blood smears for blood cells, demonstration of Western Blot Analysis and ELISA, Immunofluorescence staining of B and T Cells. Study of Vaccination chart for infants.

Second Semester ELECTIVE (2)- Endocrinology lab:

1. Dissection and display of Endocrine glands in laboratory bred rat*
2. Study of the permanent slides of all the endocrine glands
3. Demonstration of Castration/ ovariectomy in laboratory bred rat*
4. Estimation of plasma level of any hormone using ELISA kit

ZOOLOGY

M.Sc. (FINAL) SEMESTER III

PAPER I- HISTOLOGY AND HISTOCHEMISTRY:

THEORY

Unit-I: Fixation and Fixatives. Types of fixatives. Chemistry of fixation. Choice of Fixatives. Tissue processing. Dehydration. Clearing and embedding.

Unit-II: Microtomy. Types of microtomes. Sectioning paraffin blocks. Staining of paraffin sections. Principle and methods of staining. Histological stains. Haematoxylin and Eosin.

Unit-III: Principles and methods of histochemical localization and identification of the following: Carbohydrate moieties Glycogen and glycoproteins with oxidizable vicinal diols by Periodic acid Schiff method Glycoproteins with carboxyl groups and/or O-sulphate esters by Alcian blue methods, Protein end groups General proteins by Bromophenol blue method–NH_2 groups by Ninhydrin-Schiff method - SS groups by Performic acid –Schiff and performic acid- alcian blue methods

Unit-IV: Principles and methods of histochemical localization and identification of the following: Lipid moieties General lipids by Sudan black B method Neutral lipids by total Sudan III and Sudan IV methods Nucleic acids Methyl green pyronin for DNA and RNA Feulgen reaction for DNA Enzymes: Acid and alkaline phosphatases by Metal precipitation and Azo dye methods. Immunocytochemistry: Basic principles. Fluorescence histochemistry: Basic principles.

Suggested literature:

1. Bancroft, J.D. & Stevens, A. Theory and Practice of Histological techniques, Churchill Livingstone, 2002
2. Casselman, W. G. B: Histochemical techniques, John Wiley, 1959
3. Pearse A.G.E.: Histochemistry; Theoretical and Applied (Vol. I, II & III), (4th ed.), Churchill Livingstone
4. Prabhu and Shagirtha: Tools and Techniques in life Sciences, Lambert Academic Publishing
5. Kingsbury B. F: Histological technique- A Guide for use in a Laboratory course in Histology
6. Mondal S K: Manual of histological techniques, Publisher- Jaypee Brothers Medical
7. Wilson and Walker: Principles and techniques of Biochemistry and molecular Biology

ZOOLOGY

M.Sc. (FINAL) SEMESTER III

PAPER-II DEVELOPMENTAL BIOLOGY:

THEORY

Unit-I: Basic concepts of development: Potency, commitment, specification, competence, Induction, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit-II: Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals.

Unit-III: Morphogenesis and organogenesis in animals: Axes and pattern formation in *Drosophila*, amphibia and chick; Organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development; differentiation of neurons, Environmental regulation of normal development; sex determination.

Unit-IV: Post embryonic development- regeneration in vertebrates, metamorphosis in insects and amphibia; Programmed cell death, aging and senescence

Suggested literature:

1. Developmental Biology: T. Subramaniam, (Reprint) 2013, Narosa Publishing House Pvt. Ltd., New Delhi
2. Essential Developmental Biology: Jonathan M. W. Slack, (3rd ed.) 2012, Wiley-Blackwell.
3. Developmental Biology: From a Cell to an Organism (Genetics & Evolution) eBook: Russ Hodge, 2009, Infobase Publishing.
4. Current Topics in Developmental Biology: Roger A. Pedersen, Gerald P. Schatten, 1998 Elsevier.
5. Developmental biology: Werner A. Müller, 2012, Springer Science & Business Media.
6. Human Embryology and Developmental Biology E-Book: Bruce M. Carlson, 2018, Elsevier Health Sciences.
7. Developmental Biology: Michael J. F. Barresi, Scott F. Gilbert, 2019, Oxford University Press.

ZOOLOGY

M.Sc. (FINAL) SEMESTER III

PAPER III- ELECTIVE (1):
MORPHOLOGY, PHYSIOLOGY & DEVELOPMENT OF FISHES:

THEORY

Unit-I: Outlines of functional morphology (origin of paired fins, air bladder, webberian ossicles, sound and electric organs, lateral line system).

Unit-II: Physiology of digestion, respiration, excretion, osmoregulation and reproduction (gonads, role of hypothalamo-hypophysial hormones in reproduction).

Unit-III: Trends in the classification of Fishes (Evolutionary and Genealogical) Systematics and bionomics of at least one important fish from following fish orders (with particular reference of Uttar Pradesh): Beloniformes, Clupeiformes, Mastacembeliformes Mugiliformes, Cypriniformes (Cyprini and Siluri), Ophiocephaliformes, Perciformes

Unit- IV: Breeding Techniques: Bundh breeding: Types of bundhs: a) dry bundhs b) Wet bundhs c) Modern bundhs Artificial fertilization by stripping, Induced breeding by hypophysation: Definition, Hormones responsible for induced breeding, Dissection and removal of pituitary gland, Preservation and storage of pituitary gland, Preparation of gland suspension for injection and dosage. Collection, rearing and selection of brooders, Synthetic hormones used in induced breeding.

Suggested literature:

1. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and 1BH)

2. Evans: The Physiology of Fishes (2006, CRC Press)

3. Hoar & Randall: Fish Physiology, Series Vol. I - XIV (1979-2006, Academic Press)

4. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)

5. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)

6. Lagler et al.: Ichthyology (2003, John Wiley)

7. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)

8. Pillar Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)

9. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)

10. Bone and Moore: Fish Biology

ZOOLOGY

M.Sc. (FINAL) SEMESTER III

PAPER III- ELECTIVE (2):
TAXONOMY, MORPHOLOGY AND PHYSIOLOGY OF INSECTS
THEORY

Unit-I: Study of the morphology, development, metamorphosis and evolution of insects.

Unit-II: Physiology of digestion, excretion; metamorphosis and diapause including endocrine aspects.

Unit-III: An outline classification of insects; characters and identification of the economically important families. Social insects and Insect hormones.

Unit-IV: The distribution and bionomics of the following order: Thysanura, Orthoptera, Diptera, lsoptera, Mallophaga, Hemiptera, Dictyoptera, Thysanoptera, Lepidoptera, Hymenoptera and Coleoptera.

Suggested literature:

1. Chapman: The Insects: structure and function (4th ed, 1998, ELBS)
2. lmms: A general text book of Entomology, 2 vols (1997, Asia Publishing House)
3. McGavin: Essential Entomology (2001, Oxford Univ Press)
4. Srivastava: A text book of applied Entomology, Vol I & II , Kalyani Publishers.
5. Wigglesworth: Principles of Insect Physiology (1972, ELBS)
6. Gullan and Cranston: The Insects: An outline of entomology (5th ed, 2014, Wiley Blackwell)

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M.Sc. (FINAL) SEMESTER III

Practical: Time: 6 hours

Exercises	Distribution of Marks:
Dissection	15 marks
Histology	10 marks
Developmental Biology	05 marks
Fishery/ Entomology	10 marks
Spotting (10 spots)	20 marks
Viva voce	7 marks
Class records	8 Marks

Total Marks: 100 (25- internal evaluation + 75- external examination)

HISTOLOGY AND HISTOCHEMISTRY LAB: Microtomy and staining: Hematoxylin-eosin – Demonstration, Histopathology: Study of histopathological changes (permanent slides) – gastric ulcers, cirrhosis of liver, breast tumors, cystic follicles of ovary, pancreas in diabetics, cryptorchid testis and leukemia. Histochemistry: Histochemical localization of glycogen in rat/mouse liver by Bauer Feulgen technique. To study different cell types such as buccal epithelial cells, neurons, striated muscle cells using Methylene blue.

DEVELOPMENTAL BIOLOGY PRACTICALS

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture
4. Study of different sections of placenta (photomicropgraph/ slides)
5. Project report on *Drosophila* culture/chick embryo development

ELECTIVE (1)- Practical lab: FISH AND FISHERIES

1. Morphometric and meristic characters of fishes
2. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera, Exocoetus*, *Hippocampus*, *Gambusia*, *Labeo, Heteropneustes, Anabas*
3. Study of different types of scales (through permanent slides/ photographs).
4. Study of crafts and gears used in Fisheries
5. Study of air breathing organs in *Channa, Heteropneustes, Anabas* and *Clarias*

6. Demonstration of induced breeding in Fishes (video)
7. Demonstration of parental care in fishes (video)
8. Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

Dissection of Cranial nerve, Weberian ossicles, air bladder, and accessory respiratory organ of fishes.

ELECTIVE (2)- Practical lab: ENTOMOLOGY

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation.
5. Study of insect spiracles
6. Methodology of collection, preservation and identification of insects.
7. Morphological studies of various castes of *Apis, Camponotus* and *Odontotermes*
8. Study of any three insect pests and their damages
9. Study of any three beneficial insects and their products

Field study of insects and submission of a project report on the insect Biodiversity.

Dissection of Sting apparatus of Honey bee, Reproductive system of Scorpion, Nervous system of cockroach and Grasshopper

- Research Project -

ZOOLOGY

M.Sc. (FINAL) SEMESTER IV

PAPER-1: GENETICS AND MOLECULAR BIOLOGY

THEORY

Unit-I: Mendelian principles: Dominance, segregation, independent assortment. Concept of gene: Allele, multiple alleles, Pseudoalleles, complementation tests, Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Unit-II: Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping using somatic cell hybrids. Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes. Human genetics: Pedigree analysis, Lod score for linkage testing, karyotypes, genetic disorders. Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. Mutation: Types, causes and detection, Structural and numerical aberrations of chromosomes.

Unit-III: DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination). RNA synthesis machinery (transcription factors, formation of initiation complex, transcription activator and repressor), RNA processing (Capping, elongation, and termination, RNA editing, splicing, and polyadenylation), Structure and function of different types of RNA and RNA transport.

Unit-IV: Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post-translational modification of proteins). Control of gene expression (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

Suggested literature:

1. Concepts of Genetics by William Klug, Pearson
2. Fundamental of human genetics by Sanjay Madsal, New Central Book Agency, Londo
3. Genetics by P.K Gupta, Rastogi publication
4. Genetics by E. Conrad, Apple academics press
5. Modern Genetics Analysis: Integrating genes and genome, by Griffiths et al., W.H. freeman and company, New York, USA
6. Genes by Lewin, Jones and Bartlen Publishers, Boston, USA
7. Molecular Cell Biology: Lodish et al, Freeman & Co, USA (2004).
8. Molecular Biology of the Cell: Alberts et al Garland (2002).
9. Karp: Cell and Molecular Biology: Wiley (2002). Pierce B. Genetics. Freeman (2004).

ZOOLOGY

M.Sc. (FINAL) SEMESTER IV

PAPER-II BIOLOGICAL TOOLS AND TECHNIQUES

THEORY

Unit-1: Centrifugation; Principle, types and Applications; Principle and Uses of analytical instruments; Flame photometry and Spectrophotometry.

Unit-2: Separation and identification of biomolecules by Chromatography: Paper and thin layer Chromatography, Gel exclusion Chromatography, High performance Liquid Chromatography (HPLC), Affinity Chromatography.

Unit-3: Electrophoresis techniques: General principles, Support media; Electrophoresis of proteins and nucleic acid; capillary Electrophoresis, Principles of differential and density centrifugation.

Unit-4: Recombinant DNA techniques; Restriction Enzymes, Cloning Vectors, Preparation and Screening of cDNA and Genomic DNA libraries, Southern and Northern Hybridization, PCR; Principles and Applications. Detection of Proteins, DNA-Protein and Protein-Protein interaction; Western Blotting, DNA Foot Printing, EMSA.

Suggested Literature:

1. Essential Laboratory Techniques by S.R. Gallagher, E.A. Wiley.
2. An introduction to Practical Biochemistry by D.T. Plummer.
3. Bio Instrumentation: Tools and Techniques by Baig and Sinha, IIP International publishers
4. Tools and Techniques in Modern Biological Sciences, S Mukherjee, lambert
5. Recombinant Protein Expression in Mammalian cells, Methods and protocols by D L Hacker, Humana Press
6. PCR Methods and Protocols, L. Domingues, Humana Press
7. Biotechnology by Satyanarayana and Chakrapani, Books and Allied Ltd
8. Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition by Keith Wilson and John Walker, Cambridge University Press.
9. Light Microscopy in Biology: A practical Approach, 2nd Edition by Alan J. Lacey, Oxford University Press.
10. Electron Microscopy: Principles and Techniques of Biologist by John J. Bozzola, Lonnie D. Russell, Jones & Bartiett Publ.

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M.Sc. (FINAL) SEMESTER IV

PAPER III- BIOSTATISTICS AND BIOINFORMATICS

THEORY

Unit-1: Biostatistics Introduction, Descriptive and Inferential statistics, Types of data, Sampling technique: methods of sampling, choices of sampling methods, sampling and non-sampling errors: tabulation and graphic representation of data; Frequency distribution, tabulation, bar diagram, histogram, pie diagram; Measures of Central tendency; Mean, Median, Mode,

Unit-2: Measures of dispersion: variance and standard variation, coefficient of variation, ANOVA, measures of skewness, coefficient of skewness, kurtosis; probability: theorems on probability, application of permutation and combination, Test of significance-t, F, Chi-square test; Correlation and Linear Regression.

Unit-3: Bioinformatics; Introduction and scope of Bioinformatics, Archiving and retrieval of information; Search engines, databases (Nucleic acid sequences, genomes, protein sequence and structure, bibliographic), Access to molecular biology databases {Entrez, Sequence retrieval system (SRS), Protein identification resource (PRI)}, Sequence alignment and Phylogenetic tree.

Unit-4: Basic components of computer- hardware (CPU, input, output, storage devices), software (operating systems). Application software: Introduction to MSWORD word processor- editing, copying, moving, formatting, table insertion, drawing flowcharts, etc., Introduction to PowerPoint, image and data handling. Introduction to M S EXCEL use of worksheet to enter data, edit data, copy data, move data; use of inbuilt statistical functions for computation of mean, S.D., correlation and regression, graphical tools in excel for presentation of data.

Suggested literature:

1. Biostatistical Analysis Fifth ed. Jerrold H Zar, Pearson
2. Biostatistics by P N Arora and P.K Malhan, Himalaya publishing house
3. Principles of Biostatistics by Pagano M. Gauvreau, K (2000), Duxbury press, USA
4. Fundamental of Biostatics by I A Khan and A Khanam, Ukaaz publication, Hyderabad
5. Barnes & Grey (ed): Bioinformatics for geneticists, Wiley (2003)
6. Lesk: Bioinformatics, Oxford (2003, Indian ed)
7. Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)

ZOOLOGY

M.Sc. (FINAL) SEMESTER IV

PAPER IV: ELECTIVE (1): APPLIED ICHTHYOLOGY

THEORY

Unit-I: Cold water, Estuarine and Marine Fisheries of India, Fish farming in India: Type of fish farming, Fish ponds, Physico-chemical and biological characteristics of Ponds, Manuring and fertilization of fish ponds, Control of weed and Predators.

Unit-II: Fish seed production and management: Induced Breeding; Hatcheries, Spawning, collection, rearing, stocking, and transport of fish.

Unit-III: Methods of Fishing, Fishing Gears & Crafts with particular reference to Uttar Pradesh, Important Exotic fishes; Larvivorous fishes and Public Health; Fish as food and fish by products; Diseases of food fishes.

Unit-IV: Principles and methods of Fish Preservations: Traditional and advanced methods of fish preservation- sun- drying, salt drying, pickling, smoking, chilling, freezing, canning etc., Invasive fish species and their impact on indigenous fishes. Aquarium fishes and their maintenance.

Suggested Literature:

1. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
2. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
3. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, John Wiley)
4. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
5. Singh: Advances in Fish Research, Vol. land II (1993 and 1997, Narendra Publishing House)
6. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
7. Pillay: Aquaculture; Principles and Practices: Fishing News Books; (2005, First Indian reprint)

ZOOLOGY

M.Sc. (FINAL) SEMESTER IV

PAPER IV- ELECTIVE (2): APPLIED ENTOMOLOGY

THEORY

Unit-I: Principles and methods of different types of insect control with special reference to cultural, biological and chemical control. Fundamentals of chemistry, properties, formulation of insecticides; brief description of appliances employed.

Unit-II: Mode of action of insecticides and physiology of insect resistance to insecticide. Some economically important pests with particular reference to biology and control of the following: Pests of food grain and food products: Sitophilus oryzae, Rhizopertha denimida, Trogoderma, Tribolium casteneum, Callosobruchus chinensis, Sitotrega cerealella, Coreyra cephalonica. Pests of cotton: Dysdercus koenijii, Pectinophora gossypiella, Pests of sugarcane: Pyrilla perpusilla, Tryporhiza nivella, Pests of crops yielding cereal products: Leptocorisa varicornis, Locust, Pests of oilseed, fruits and vegetables: Aulacophora fovecollis, Bagrada picta, Idiocerus atkinsoni.

Unit- III: Ecological factors governing insect development and metamorphosis. Bee keeping, Lac and Silk industry in India. Plant protection and extension entomology in India.

Unit IV:Pests of Public importance and their control- Mosquito, house fly, bed bug, lice, Fleas, Insect borne diseases of man- Typhus, yellow fever, dengue, encephalitis, plague, Leishmaniasis, Sleeping sickness, Malaria, Filaria,Insect venom and allergens, Insect succession on corpse, Determination of time of Death.

Suggested Literature:

1. David and Ramamurthy: Elements of Economic Entomology (6th ed.), Namrutha, 2011
2. Gullan & Cranston, The Insects: An Outline of Entomology (5th ed.) Wiley Blackwell, 2014
3. Imms: A General Text Book of Entomology (2 vols.), Asia Publishing House, 1997
4. lshaaya and Degheele: Insecticides with novel modes of action: Mechanism and Application Springer-verlag, 1998
5. Ishaaya: Biochemical sites of insecticide action and resistance Springer-Verlag, 2001
6. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002

RESEARCH PROJECT/ DISSERTATION