Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

Post Graduate Teaching Department of Zoology (Autonomous)

Syllabus for M.Sc. (Zoology) Program Choice Based Credit System (CBCS) As Per NEP-2020

Effective From 2023-24

SCHEME OF TEACHING & EXAMINATION AND SYLLABUS AS PER NEP 2020 for M. Sc. ZOOLOGY (AUTONOMOUS) Choice Based Credit System (Semester Pattern) Effective from 2023-2024

M.Sc. Zoology (CBCS) Program: M.Sc. Zoology is a 4-semester course offered by The Post Graduate Department of Zoology which has been granted Academic Autonomy (Direction 14 of 2022), by The Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur. All four semesters comprise of four theory papers. In addition, First semester under study consists of two skill-based Practicals while Second semester entails an On Job Training (OJT) along with two skill-based Practicals. Furthermore, Third semester comprises of one skill based practical based on electives and a Minor Research Project. The Fourth semester comprises of Major Research Project.

Program Outcomes (PO)

PO 1- M.Sc. program produces post-graduates who have great readiness in playing active role either in government or non-government organization by designing processes/strategies that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 2- Students developed analytical and creative thinking from the conducive research environments and interacting with scholars/ faculties that will help in identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO 3- To use research-based knowledge and research methods including review research literature, accession of primary literature, identify relevant works for a particular topic, design of experiments, analysis, evaluation and interpretation of scientific data, and synthesis of the information to provide valid conclusions in real situations.

PO 4- To empower students to create, select, and apply appropriate techniques, resources, and ICT tools for understanding of the science.

PO 5- Apply ethical principles and commit to professional ethics and responsibilities and norms of the work/research practice. Also, to promote learning and research aptitude and attitude to serve the society.

PO 6- Students are encouraged to develop an analytical mind as they ask questions, take part in topic-based quiz and debates, and are made aware of recent study and research on relevant topics.

PO 7- To enhance the ability of writing research project activities, problem-solving, to design and carry research project.

PO 8- M.Sc. program produces post-graduates who have great confidence which allows them to have a positive and realistic perception of themselves and their abilities in the scientific and social environment.

PO 9- Students acquiring skill-based education will make them self-employable and can generate employment.

PO 10- Students are encouraged to develop analytical and critical thinking minds which will help to develop scientific temperament in the community.

Program Specific Outcomes (PSO)

PSO 1- Students will acquire techniques and skills to implement the knowledge in the design and execution of research in different branches of Zoology. This will help in careers related to teaching, research in Zoology; as well as in having innovative ideas and necessary training to initiate unique start-ups and entrepreneurship in the realm of life sciences.

PSO 2- To learn and apply the ethics in animal handling, during laboratory practices and experimentation.

PSO 3- In addition to the curriculum, the students will also gain skill-based learning, practical knowledge to facilitate experiments in the subject Zoology.

PSO 4- Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. Demonstrate knowledge and understanding of Zoology and management principles and apply these to one's own work, as a member and leader in a team.

PSO 5- To acquired knowledge across a broad range of Zoology including recent trends which will help to solve the scientific problem logically in the context of biological process. Thus, leading to self-directed learning and evaluation.

PSO 6- Perform laboratory procedures as per standard protocols in various areas of Zoology including Animal Diversity, Cell Biology, Genetics, Molecular Biology, Physiology, Developmental Biology, Comparative Endocrinology, Immunology, Mammalian Reproductive Physiology, Fish and Fisheries and Entomology.

PSO 7- Understand the applications of zoological science in Apiculture, Sericulture, Lac culture, Fish and Fisheries, Mammalian Reproductive Physiology and Animal Physiology.

PSO 8- Develop knowledge and understanding of living organisms at several levels of Zoological and Biological organization from molecular level, through cells and ultimately the whole organisms and its impact on ecosystems.

PSO 9- To develop interest and elective modules by selecting specialization in various aspects and understanding the methods of zoological research.

PSO 10- The M. Sc. Program will lead the students to impart a scientific temperament which will help them to add new scientific knowledge/information in the field of Zoology research.

Scheme of teaching and examination for M. Sc. ZOOLOGY (CBCS) As per NEP 2020
Structure and Credit Distribution of PG Degree Program for Two years
Choice Based Credit System (Semester Pattern)
Effective from 2023-2024

M. Sc. Zoology Semester I											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
						Duration in hours	Max. Marks		Total Marks	Minimum Passing Marks	
		Theory	Practical	Total			External	Internal		Theory	Practical
PGZO1T1	**Paper-1T1** Structure and Function of Invertebrates	4	-	4	4	3	60	40	100	50	
PGZO1T2	**Paper-1T2** Cell Biology and Genetics	4	-	4	4	3	60	40	100	50	
PGZO1T3	**Paper- 1T3** Electives (**Select any one**) **1.** Mammalian Reproductive Physiology in Male **2.** Digestive and Excretory Physiology **3.** General Fish Biology **4.** General Entomology	4	-	4	4	3	60	40	100	50	
PGZO1T4	**Paper-1T4** Research Methodology	4	-	4	4	3	60	40	100	50	

PGZO1L1	Practical **1L1:** Based on Theory paper 1T1	-	6	6	3	3-6*	50	50	100		50
PGZO1L2	Practical **1L2:** Based on Theory paper 1T2	-	6	6	3	3-6*	50	50	100		50
	TOTAL	**16**	**12**	**28**	**22**		**340**	**260**	**600**	**200**	**100**

	M. Sc. Zoology Semester II											
Code	Theory / Practical	Teaching scheme (Hours / Week)				Credits	Examination Scheme					
							Duration in hours	Max. Marks		Total Marks	Minimum Passing Marks	
		Theory	Practical	Training	Total			External	Internal		Theory	Practical
PGZO2T1	**Paper-2T1** Structure and Function of Chordates	4	-	-	4	4	3	60	40	100	50	
PGZO2T2	**Paper- 2T2** Advanced Developmental Biology	4	-	-	4	4	3	60	40	100	50	
PGZO2T3	**Paper-2T3** Electives (**Select any one**) 1. Mammalian Reproductive Endocrinology **2.** Brain and Muscle Physiology **3.** Economic Aquaculture **4.** Insect Morphology and Physiology	4	-	-	4	4	3	60	40	100	50	

PGZO2T4	**Paper-2T4** On Job Training	-	-	4	4	4	3	60	40	100	50	
PGZO2L1	**Practical 2L1:** Based on Theory 2T1	-	6	-	6	3	3-6*	50	50	100		50
PGZO2L2	**Practical 2L2:** Based on Theory 2T2	-	6	-	6	3	3-6*	50	50	100		50
	TOTAL	**12**	**12**	**04**	**28**	**22**		**340**	**260**	**600**	**200**	**100**

M. Sc. Zoology Semester III												
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme						
						Duration in hours	Max. Marks		Total Marks	Minimum Passing Marks		
		Theory	Practical	Total			External	Internal		Theory	Practical	
PGZO3T1	**Paper-3T1** Parasitology and Immunology	4	-	4	4	3	60	40	100	50		
PGZO3T2	**Paper- 3T2** Wild Life and Avian Biology	4	-	4	4	3	60	40	100	50		
PGZO3T3	**Paper-3T3** Comparative Endocrinology	4	-	4	4	3	60	40	100	50		

PGZO3T4	**Paper-3T4** Electives (**Select any one**) **1.** Mammalian Reproductive Physiology in Female **2.** Blood and Cardiac Physiology **3.** Fish Physiology **4.** Insect Pest Management	4	-	4	4	3	60	40	100	50	
PGZO3P1	**Practical 3P1:** Practicals on electives	-	6	6	3	3-6*	50	50	100		50
PGZO3P2	Research Project (RP) Minor Work	-	6	6	3	3-6*	50	50	100		50
	TOTAL	**16**	**12**	**28**	**22**		**340**	**260**	**600**	**200**	**100**

M. Sc. Zoology Semester IV											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
						Duration in hours	Max. Marks		Total Marks	Minimum Passing Marks	
		Theory	Practical	Total			External	Internal		Theory	Practical
PGZO4T1	**Paper-4T1** Biotechnique, Biostatistics, Ethology, Toxicology and Bioinformatics	4	-	4	4	3	60	40	100	50	

PGZO4T2	**Paper- 4T2** Radiation and Chronobiology	4	-	4	4	3	60	40	100	50	
PGZO4T3	**Paper-4T3** Molecular Biology and Biotechnology	4	-	4	4	3	60	40	100	50	
PGZO4T4	**Paper-4T4** Electives (**Select any one**) **1.** Mammalian Reproductive Toxicology **2.** Respiratory and Reproductive Physiology **3.** Fishery Technology and Fish Pathology **4.** Medical, Veterinary and Industrial Entomology	4	-	4	4	3	60	40	100	50	
PGZO4P2	Research Project (RP) Major Work	-	12	12	6	3-6*	100	100	200	-	100
	TOTAL	**16**	**12**	**28**	**22**		**340**	**260**	**600**	**200**	**100**

NoteY **Th** Á Theory; **Pr** Á PracticalNlab, l Á If required, for two daysM

Semester-I

PGZO1T1 Paper-1T1, Structure and Functions of Invertebrates

Course Outcomes (COs)

Students will be able to identify, classify, describe, discuss and explain invertebrate specimen in the field as well as maintain and organize museum specimen. Develop a skill to demonstrate and explain different anatomical systems, physiological body processes and diversity of invertebrates, animal architecture and functions. Create the awareness of the economic importance, significance and explain structural and functional relationship between invertebrate phyla. Assess and evaluate a taxonomic status of primitive members of arthropods and molluscs. Describe and analyze the sea star's body plan, elucidate the origins and evolutionary significance of echinoderm larval forms, comprehend the mechanism of movements based on fluid filled cavities in invertebrates and identify and classify minor invertebrate specimen. Perform the whole mount preparations of given invertebrate material.

Semester-I

PGZO1T1 Paper-1T1, Structure and function of Invertebrates

Unit-I

1.1 Basic concepts of biosystematics, taxonomy and classification. Recent trends in biosystematics: Chemotaxonomy, Cytotaxonomy and Molecular taxonomy.

1.2 Ultra structure of locomotory organs and locomotion in Protozoa.

1.3 Origin of metazoan-colonial, syncytial and molecular theories.

1.4 Dermal cell and skeleton of Porifera. Canal system in sponges.

Unit-II

2.1 Comparative account of Coelenterata and Ctenophora: Structure and Reproduction.

2.2 Reproductive system and reproduction in Helminths.

2.3 Classification of coelomates based on coelom formation, metamerism and Symmetry.

2.4 Excretory system and excretion in Annelida.

Unit-III

3.1 Filter feeding mechanism in Invertebrates

3.2 Organs and Mechanism of respiration in Arthropoda and Mollusca

3.3 Affinities and taxonomic position of *Peripatus* and *Neopilina*.

3.4 Neuroanatomy in Gastropoda, Bivalvia and Cephalopoda.

Unit-IV

4.1 Water vascular system in Echinodermata: structure and functions.

4.2 Larval forms in Echinodermata: Metamorphosis and phylogenetic significance.

4.3 Principles of hydrostatic skeleton and Locomotion based on hydrostatic skeleton in Invertebrates

4.4 Systematic position, general organization and affinities of Bryozoa and Rotifera.

Semester I

PGZO1T2 Paper-IT2, Cell Biology and Genetics

Course Outcomes (COs)

Students will be able to describe and explain the structure and function of plasma membrane through fluid mosaic model, types of membrane proteins, transport and organization of cytoskeleton, cell organelles and endomembrane system. Differentiate and illustrate the mechanism of Cell division, cell cycle regulation, types of cell signalling, signal transduction pathways and various receptors involved in cell signalling. Describe and differentiate the types and functions of cellular communication, cell adherence molecule and extracellular matrix interaction. Differentiate Mendelian, non-Mendelian inheritance and solve the problems of inheritance based on probability. Explain, differentiate and compare codominance, incomplete dominance, gene interactions, linkage, crossing over, sex limited and sex influenced characters. Illustrate and differentiate the mode of inheritance of polygenic and monogenic traits, role of genetic and environmental factors of inheritance, inbreeding and its consequences and deduce coefficient of inbreeding and consanguinity. Explain, distinguish and describe the mutation and its types, structural and numerical alterations of chromosomes as well as the extra chromosomal inheritance, maternal inheritance, microbial genetics, genetic mapping and human genetics by using pedigree analysis and types of genetic disorders. They could demonstrate metaphasic chromosomes, Barr body and Polytene chromosomes.

Semester-I

PGZO1T2 Paper-1T2, Cell Biology and Genetics

Unit-I

1.1 Membrane structure and function - Structure of model membrane. Organization and properties of membrane lipids. Organization and properties of membrane proteins. Membrane of human red blood cell. Transport of substances through membrane- Diffusion. Facilitated diffusion. Active transport (Primary and secondary).

1.2 Structural organization and functions of cell organelles- nucleus, mitochondria, endoplasmic reticulum, Golgi complex, lysosomes and peroxisomes, endomembrane system.

1.3 Organization of Cytoskeleton- Structure and function of microtubules, microfilaments and intermediate filaments.

1.4 Cell division and cell cycle - phases of cell cycle, checkpoints of cell cycle, regulation of cell cycle, mitosis, meiosis.

Unit-II

2.1 Cell signaling - hormones and their receptors, signaling through G- protein coupled receptors, Receptor protein- tyrosine kinase and ion channel receptors.

2.2 Signal transduction pathways, primary and secondary messenger systems, regulation of signaling pathways.

2.3 Cellular communication – Cell-cell interaction. Cell adhesion molecules (Selectins, Immunoglobulin superfamily, Cadherins). Adherens junctions and desmosomes. Tight junctions. Gap junctions.

2.4 Cellular communication - Cell – Extracellular matrix interaction. Organization and components of extracellular matrix. Interaction of cell with extracellular matrix (Integrins, focal adhesions and hemidesmosomes).

Unit-III

3.1 Mendelian inheritance- Mendelian Principles, Mono / dihybrid inheritance. Exercises for solving genetics problems.

3.2 Extensions of Mendelian principles - codominance, incomplete dominance, gene interactions, linkage and crossing over, sex linkage, sex limited and sex influenced characters and multiple allelism.

3.3 Quantitative Genetics - polygenic traits and mode of inheritance, genetic and environmental factors, heritability, inbreeding and consequences, coefficient of inbreeding and consanguinity.

3.4 Mutation - types, causes and detection, mutant types- lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants.

Unit-IV

4.1 Structural and numerical alterations of chromosomes - deletion, duplication, inversion, transversion, translocation, ploidy and their genetic implications.

4.2 Extra chromosomal inheritance - cytoplasmic inheritance, inheritance of mitochondrial genes, maternal inheritance.

4.3 Microbial genetics - recombination in bacteria and gene mapping, transformation, conjugation, transduction (generalized and specialized), fine structure mapping of genes.

4.4 Human genetics- Pedigree analysis. Karyotypes. Genetic disorders (Huntington's disease, Phenylketonuria, Alkaptonuria, Albinism, Sickle cell anemia, Thalassemia, Cystic fibrosis).

Semester I
PGZO1T3 Paper-1T3, Electives

1. Mammalian Reproductive Physiology in Male

Course Outcomes (COs)

Students will be able to describe and demonstrate the development processes and functions of different units of testis. Deduce the structure, functions, regulation, anomalies and disease of male reproductive and accessory reproductive organs and understand the mechanism of sperm capacitation. Explain and discuss the role of hormones in the regulation of reproductive behaviour and types of breeding systems. Recognize and identify structural and functional aspect of different types of pheromones. Illustrate and counsel about the factors responsible for infertility. Assess and describe reproductive health dysfunction affected by aging in males. They could able to demonstrate fructose, acid and alkaline phosphatase, sialic acid and sperm count analysis.

Semester-I

PGZO1T3 Paper-1T3, Electives

1. Mammalian Reproductive Physiology in Male

UNIT -I

1.1 Development, descent and structure of the testis.

1.2 Spermatogenesis: Molecular changes, hormonal regulation, and spermiogenesis.

1.3 Sertoli cells: Structure, functions, blood testes barrier.

1.4 Leydig cells: Structure, functions and interaction with peritubular and Sertoli cells.

UNIT II

2.1 Epididymis Structural organization and function.

2.2 Structure of spermatozoa, functions and anomalies.

2.3 Sperm capacitation: molecular and biochemical changes, decapacitation.

2.4 Vas deferens: Structure and function.

UNIT -III

3.1 Seminal Vesicle: Structure, function and regulation.

3.2 Prostate gland: Structural organization, function, endocrine regulation and prostatic cancer.

3.3 Cowper's gland: Structure, function and anomalies.

3.4 Penis: Structure and mechanism of erection and problems in ejaculation.

UNIT -IV

4.1 Male reproductive behaviour: Mating system, neural and hormonal control.

4.2 Pheromones: types, structure and function.

4.3 Infertility in male: causes, symptoms, diagnosis and remedy.

4.4 Andrology: reproductive health dysfunction in advanced age.

Semester-I

PGZO1T3 Paper-1T3, Electives

2. Digestive and Excretory Physiology

Course Outcomes (COs)

The students will be able to differentiate and compare the types, anatomical structures, secretory and endocrine cells present in the histological structure, mechanism of secretion along with the neural and chemical control secretion of different digestive glands such as the salivary gland, stomach, pancreas, liver and intestine etc. along with movement of GIT. Demonstrate the effects of various factors on the activity of digestive enzymes. Describe, explain and compare gut brain axis, mechanism of digestion of various biomolecules such as carbohydrates, proteins and lipids and disorders associated with the GIT. Describe, explain and compare the anatomy of kidney, types and ultrastructure of nephron, mechanism of urine formation, concentration and dilution of urine and normal and abnormal constituents of urine along with micturition. Determine the regulation of urine and body fluid concentration and volume along with water, electrolyte and acid base balance.

Describe, explain and compare mechanism of ADH, RAAS system, renal clearance, physiology of nitrogen excretion and causes, symptoms and treatments of renal failure. They will be able to qualitatively demonstrate the presence of various normal and abnormal constituents of urine. Further, they will demonstrate the presence of normal and abnormal urine crystals.

Semester-I

PGZO1T3 Paper-1T3, Electives

2. Digestive and Excretory Physiology

UNIT -I

1.1 Histology of salivary glands, Mechanism of salivary secretion, composition and functions of saliva.

1.2 Histology of stomach, mechanism of secretion of gastric juice, composition and functions of gastric juice.

1.3 Histology of pancreas, mechanism of pancreatic secretion, composition and functions of pancreatic juice.

1.4 Histology of liver, bile secretion, its composition and functions.

UNIT -II

2.1 Histology of small and large intestine, intestinal glands, its secretion and control, gut brain axis**.**

2.2 Digestion and absorption of proteins, carbohydrates and fats in the gastrointestinal tract.

2.3 Neural and endocrine regulation of gastro intestinal movements and secretions.

2.4 Gastrointestinal Disorders (Achalasia, Gastritis, Pancreatitis and Colitis).

UNIT -III

3.1 Functional anatomy of kidney- Types and ultrastructure of Nephron, blood and nerve supply.

3.2 Mechanism of formation of urine- Ultrafiltration, tubular reabsorption, tubular secretion and its regulation.

3.3 Mechanism of concentration and dilution of urine – The Counter current system.

3.4 Normal and abnormal constituents of urine, micturition and its control.

UNIT -IV

4.1 Regulation of urine and body fluid concentration and volume, hormonal mechanism of Antidiuratic hormone, Aldosterone and Renin – Angiotensin system in renal physiology.

4.2 Regulation of water, electrolytes and acid base, renal clearance.

4.3 Physiology of nitrogen excretion

4.4 Renal failure- Acute and chronic renal failure, renal diuretics diagnosis, symptoms and treatment

Semester-I

PGZO1T3 Paper-1T3, Electives

3. General Fish Biology

Course Outcomes (COs)

Students will be able to explain and describe the evolutionary significance of fishes through the concepts of origin, classification and general characters of Ostracoderms, Placoderms and Chondrichthyes. Explain, describe and compare general characters and classify different ranks of Superorder Pisces. Identify different marine and freshwater fishes. Explain and describe peculiarities and affinities of Dipnoi, comparative account of accessory respiratory organs and different systems in fishes. They could estimate CO_2, dissolved O_2 and chloride of water and protein, sodium and potassium content of blood sample in fish.

Semester-I

PGZO1T3 Paper-1T3, Electives

3. General Fish Biology

UNIT -I

1.1 Origin and Evolution of fishes: Characters and Evolutionary classification of fishes. [Berg (1940), Romer (1959), Nelson (1984) and Pough et.al. (1989)]

1.2 Ostracoderms (Euphanerida, Pterapsida, Anapsida, Cephalaspida, origin and inter relationship of Ostracoderm) and Cyclostomes (Specialized characters, relationship with fishes and Ostracoderms, Biology of Petromyzon, general characters of Lampreys and Hagfishes)

1.3 Classification and general characters of Placoderms: Acanthodii, Coccostei,

Pterychthyes, Stegoselachii, Palaeospondyli.

1.4 Chondrichthyes (Sharks, Rays and Holocephali): Classification, general characters, Affinities.

UNIT -II

2.1 Classification and general characters of Osteichthyes.

2.2 Classification and characters of Crossopterygii.

2.3 Classification and general characters of Actinopterygii/Ray finned fishes: Palaeonisciformes, Polypteriformes, Acipenseriformes, Amiiformes, Teleostea (Osteoglossomorpha, Elopomorpha, Clupeomorpha, Euteleostei).

2.4 Affinities of Actinopterygii and Crossopterygii.

UNIT -III

3.1 Dipnoi: General and Specialized characters, classification, fossil Dipnoians and distribution of Dipnoians.

3.2 Blood vascular system of Protopterus.

3.3 Respiratory system of teleost: Structure of gills in fishes, gill histology

3.4 Blood supply of a gill and mechanism of respiration in teleosts.

UNIT -IV

4.1 Accessary respiratory organs: skin, buccopharynx, alimentary canal opercular cavity, and air bladder. Origin and significance of air breathing organs.

4.2 Mechanism of air breathing, function of accessory respiratory organ.

4.3 Air bladder: Origin and evolution, types of air bladder- physostomous, physoclistous, structure of bladder walls and gas secreting complex.

4.4 Blood supply to air bladder and functions of air bladder

Semester-I

PGZO1T3 Paper-1T3, Electives

4. General Entomology

Course Outcomes (COs)

Students will able to identify, classify and differentiate the various insects belonging to different ranks. Describe, explain, and analyse insect social organization and its peculiarities. They could describe and explain structure of reproductive system, specialized reproductive mechanism, embryogenesis and metamorphosis in insects.

Semester-I

PGZO1T3 Paper-1T3, Electives

4. General Entomology

UNIT I

1.1 Modern scheme of insect classification and general characters of various Orders.
1.2 General characters and classification of Thysanura and Collembola.
1.3 General characters and classification of Mallophaga and Siphunculata.
1.4 General characters and classification of Siphonaptera.

UNIT -II

2.1 General characters and classification of Orthoptera.
2.2 General characters and classification of Hemiptera.
2.3 General characters and classification of Lepidoptera.
2.4 General characters and classification of Coleoptera.

UNIT -III

3.1 Social life: Polymorphism, nest building and social behavior in Isoptera.
3.2 Social life: Polymorphism, nest building and social behavior in ants.
3.3 Parasitic Hymenoptera-types and significance.
3.4 Locust migration and swarming.

UNIT - IV

4.1 Reproduction: male and female reproductive system, structure of testis and ovary, mechanism of spermatogenesis and vitellogenesis.
4.2 Specialized reproductive mechanism: viviparity, polyembryony, paedogenesis and parthenogenesis.
4.3 Early embryonic development up to germ band formation.
4.4 Metamorphosis: types of larvae and pupae.

Semester I
PGZO1T4 Paper-IT4, Research Methodology

Course Outcomes (COs)

Students will be able to learn, describe and imbibe animal ethics in research, as well as various guidelines provided by IAEC and CCSEA. Students will be able to compare the model organisms used in biological science. They will able to discuss and determine the animal facilities to laboratories, transportation, hygiene, environment, maintanance, ethical, legal and policy issues. Encourage students to pursue their interests in research and to investigate selecting appropriate methodology of scientific research. Students could design the experiments properly. They will be able to write scientific reports, research proposals,

patents, review articles, and will be aware of major funding agencies. Improve the knowledge of computer skills related to biology and metagenomics research. They will be able to use basic computer programmes such as MS-Office, Coral Draw, and Photoshop. Students will analyse and use statistics to analyse data in biological research. They will able to apply central tendency, dispersion, skewness, and kurtosis measures in the research work. They also learn measures of relationship tests of hypothesis testing of significance and know about statistical softwares.

Semester-I

PGZO1T4 Paper 1T4: Research Methodology

Unit-I Animal Ethics

1.1 Introduction: IAEC and CPCSEA guidelines, guidelines for human and animals use.
1.2 Model organism used in biological research: Animal models to be discussed with respect to their availability.
1.3 Animal facilities to laboratories: Transportation, hygiene, environment, maintanance and disposal.
1.4 Legal ethical and policy related issues: Historical background to the A(SP)A, recent issues of public debate, regulations requiring the use of animals.

Unit-II Research Methodology and Technical Writing

2.1 Methodology of scientific research, nature of scientific methods, design of experiments, policies in regulating research, guidelines for use of humans and animals in research and plagiarism.

2.2 Preparation of scientific reports, writing a research proposal and patent (Thinking and planning, information, ideas, order of paragraph writing, proper use of nouns, pronouns and articles, tenses, spellings etc.).

2.3 Writing of review articles: Objectives, parameters used, data obtained, summary and bibliography.

2.4 Leading funding agencies in India and Abroad.

Unit-III Computer

3.1 Introduction of computer networks- Topologies and designs; Basics of computer operating systems MS-Office.

3.2 Spreadsheets and Presentation software: Ppt, Coral draw, Photoshops, Excel and Page maker.

3.3 An introduction to computer biology.

3.4 Introduction to metagenomics.

Unit-IV Biostatistics

4.1 Specific applications of measures of central tendency, dispersion, skewness and Kurtosis in research.

4.2 Measures of Relationship: Correlation and regression, Annova (one way and two way).

4.3 Non-parametric and Parametric Tests of hypothesis, introduction to statistical softwares.

4.4 Testing of significance with respect to proportion, variance and correlation.

Semester-I, PGZO1L1 Skill based practical course in M. Sc. SEM-I Zoology, Structure and Function of Invertebrates and Physiology

1 Study of museum specimens using already available specimens in the museum/ charts/ models/ photographs/ digital alternatives etc.
Classification up to order and comments on the specimens representing all phyla.

2 Anatomical Observations
Anatomical observations, demonstration and detailed explanation of a) Digestive system of Earthworm, Leech, Cockroach, Silkworm and Honey bee b) Nervous system of Prawn, Cockroach, Silkworm and Honey bee and c) Reproductive system of Earthworm, Leech, Cockroach and Honey bee with the help of ICT tools/ Models/ Charts/ Photographs etc.

3 Mounting- Whole mount preparation of plankton and/or study of permanent preparation of the following with the help of already available permanent slides/ ICT tools/ charts/ photographs etc**.**

a. Earthworm – Nerve ring, ovary, spermatheca, nephridia.
b. Leech – jaws, ciliated organ.
c. Cockroach – Mouth parts, Salivary glands, trachea.
d. Prawn –Appendages, Statocyst.
e. Protozoans- Rhizopods, flagellates, ciliates (fresh water forms).
f. Porifera – Spicules and gemmules of fresh water sponges.
g. Crustaceans and rotifers - Planktonic copepodes, cladoceran, ostracoderm and rotifers.
h. Larval forms of the free-living invertebrates.
i. Larval forms of parasitic invertebrates.

4 Study of permanent Invertebrate slides

a. Porifera – T.S. and L.S. of *Sycon,* gemmules, spongian fibres, spicules
b. Coelenterata – T.S. of *Hydra*, T.S. of Sea anemone, Ephyra larva
c. Helminths – T.S. of *Planaria,* T.S. of *Taenia*, scolex W.M., Mature, gravid proglotids, T.S. of male and female *Ascaris*, W.M of *Ankylostoma* , *Enterbios*, *Dracunculus*, *Wuchereria*

d. Annelida -T.S. of *Nereis*, T.S. of Earthworm passing through various organs, T. S. of Leech.
e. Arthropod larvae – Nauplius, Zoea, Metazoea, Megalopa, Mysis.
f. Mollusca – T.S. of foot, Veliger and Glochidium larva.
g. Echinodermata- Pedicellarae, T.S. of arm of star fish, Bipinnaria, Oricularia larva.
h. Hemichordata – T.S. through collar, proboscis, trunk and branchio-genital regions. Tornaria larva.

5. Physiology experiments

a. Total leucocyte count and differential leucocyte count.
b. Total R.B.C. count.
c. Demonstration of action of salivary amylase, trypsin, pepsin.
d. Demonstration of rate of O_2 consumption in aquatic animals, under various environmental stresses.
e. Demonstration of haemoglobin concentration in normal and pathological condition.
f. Estimation of sodium, potassium and chloride in blood and excretory organs by Colorimeter or flame photometer (Source of blood: Local recognized pathology laboratory).
g. Estimation of glucose in blood by spectrophotometer or Colorimeter (Source of blood: Local recognized pathology laboratory).
h. Estimation of total blood proteins by spectrophotometer or Colorimeter (Source of blood: Local recognized pathology laboratory).
i. Estimation of cholesterol in blood by spectrophotometer or Calorimeter (Source of blood: Local recognized pathology laboratory).

Distribution of Marks:		**Marks**
1.	Anatomical observations	10
2.	Stained permanent preparation:	10
3.	Identification and comment on the spots (1-10)	30
4.	Physiology experiment (Major)	15
5.	Physiology experiment (Minor)	10
6.	Submission of stained permanent slides	05
7.	Class Record	10
8.	Viva-voce	10
	Total marks	**100**

Semester-I, PGZO1L2 Skill based practical course in M. Sc. SEM-I Zoology, Cell Biology and Genetics and Reproductive Biology

1. Study of mitotic metaphasic chromosomes in plant material.
2. Preparation of human karyotypes by using photographs/pictures.
3. Demonstration of Barr body in human female leucocytes.
4. Demonstration of polytene chromosome in dipteran larvae with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
5. Problems on genetics based on monohybrid/dihybrid ratios, sex linked inheritance and blood groups.
6. Study of various human genetic traits.
7. Study of different stages of spermatogenesis in grasshopper / rat with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
8. Demonstration of oogenesis in earthworm/ fish/ rat ovary with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
9. Semen analysis: physical viscosity, pH, liquefaction time, agglutination test and motility (Source of semen: Government artificial insemination centre).
10. Sperm vitality study using suitable stains (Source of semen: Government artificial insemination centre).
11. Hypo-osmotic swelling (HOS) for the assessment of normal semen.
12. Study of vaginal smear in rat by temporary mounting (methylene blue) or by permanent stained (Haematoxylin-eosin) with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
13. Histology of male and female reproductive organs and accessory reproductive glands with the help of already available permanent slides/ ICT tools/ charts/ photograph etc.

Distribution of Marks	**Marks**
1. Cytological preparation	20
2. Problems on genetics (any two)	20
3. Spermatogenesis/oogenesis/sperm vitality	15
4. Vaginal smear/hypo-osmotic test for fertility	10
5. Identification and comment on spots (1-5)	15
6. Class record	10
7. Viva-voce	10

Total Marks	**100**

Suggested Readings

- **Structure and function of Invertebrates**

1. Hyman L.H. The Invertebrate Vol. I, Protozoa through Ctenophora. McGraw-Hill Co., New York.
2. Barrington E.J.W. Invertebrate structure and function. Thomas Nelson and sons Ltd., London.
3. Jagerstein G. Evolution of Metazoan life cycle. Academic press, New York and London.
4. Hyman L.H. The invertebrate vol. 2 McGraw-Hill Co., New York.
5. Hyman L.H. The invertebrate vol. 8 McGraw-Hill Co., New York.
6. Barnes R.D. Invertebrate Zoology W.B. Saunders and Co., Philadelphia
7. Russet HunterW.D.D. biology of higher invertebrate The Macmillan Co. Ltd., London.
8. Hyman L.H. The Invertebrates, smaller coelomate groups. Vol. 5 McGraw-Hill Co. New York.
9. Read C.P. Animal Parasitism. Prentice Hall. New-Jersey.
10. Kudo R.R. (1966) Protozoology, Charler, C. Thomas Springfield, Illinois.
11. Barradailes L.A. and potts F.A. Invertebrates (1961) The Eastham L.E. S. Saunders, Cambridge University Press, Cambridge.
12. Russel W.D. Hunter, Biology of lower invertebrates McMillan, New York.
13. Marshall A.J. and Williams W.D. (1972) J. B. Zoology of Invertebrates, ElBs and McMillan, London.
14. Gtryyrt V. and Graham A. A Functional anatomy of Invertebrates. Academic press, New York.
15. Backlemiccher W.N. Principles of comparative anatomy of Invertebrates Oliver and Boyed Edinberg.
16. Hadisi J. The Evolution of Metazoa. Pergamon Press, Oxford.
17. Dales R.P. Annelids, Hutchinson, London.
18. Green J. Biology of Crustacea, Wither by, London.
19. Morton J. E. Mollusca, Hutchinson, London.
20. Nichols D. Echinodermata, Hutchincon, London.

- **Cell Biology and Genetics**

1. Cell and Molecular Biology by De Robertis- E. D. P., I. S. E. publication.
2. Molecular Biology by Turner P. C. and Mc Lennan , Viva Books Pvt. Ltd.
3. Advanced Molecular Biology by Twyman R. M., Viva Books Pvt. Ltd.
4. Molecular Biology by Freifelder D., narosa publication House.
5. Gene VI by Benjamin Lewis, Oxford press.
6. Gene VIII by Benjamin Lewis, Oxford press.
7. Molecular biology of Gene by Watson J. D. et. al., Benjamin publication.
8. Molecular cell Biology by Darnell J. Scientific American Books USA.
9. Molecular Biology of the Cell by Alberts B., Bray D. Lewis J., garland publishing Inc.
10. Genetics Vol. I and II by Pawar C. B., Himalaya publication.

11. Essentials of Molecular Biology by Freifelder D., narosa publication House.
12. Molecular Cell Biology by Laodish H., Berk A., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell J., W. H. Freeman and Co.
13. The Cell: Molecular Approch by Cooper G. M.
14. Molecular Biology by Upadhay A and Upadhay K. Himalaya publication.

- **Mammalian Reproductive Physiology in Male**

1. A textbook of in vitro fertilization and assisted reproduction edited by P.R. Brinsden and P. A. Rainsbur Jaypee brothers 1992.
2. Advances in Reproductive Physiology, Vol. 1 to 6: Mclaren, (1968). Logos Press Ltd., London.
3. Advances in Reproductive Toxicology eds. S. C. Joshi and A. S. Ansari Pointer publishers.
4. Andrology. 2nd Edition Male Reproductive health and dysfunction (Eds. E. Nieschlag & H.M. Behre) 2000.
5. Biochemistry of Mammalian Reproduction: Zanveld, L.J.D. & R.T. Chatterton (1982). John Wiley & sons, New York.The Ovary.Vol. I, II & III: Zuckerman, S, (1962). Academic Press, London.
6. Biology of Gestation: Assalye, N.S. (1968). Academic Press, London.
7. Biology of ovarian follicles in mammals (1985). S. S. Guraya Springer-Verlag.
8. Comparative cellular and molecular biology of testis in vertebrates (Trends in endocrine, paracrine and autocrine regulation of structure of functions) (2001) S.S. Guraya, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta.
9. Comparative Endocrinology and Reproduction. Eds. K.P. Joy, A. Krishna and C. Haldar, Narosa Publishing House (1998).
10. Contraceptive Technology Past, Present and Future: Das. R.P. (1989). N.I.H.F.W. New Delhi.
11. Control of ovulation: Crighton, D.B., Haynes, N.B. Foxcroft, G.R. & G.E. Lamming (1978). Butterworths, London.
12. Encylopedia of Reproduction Vol. I, II, III, IV eds. Ernst Knobil and J.D. Neill (1998).
13. Hormonal Control of Lactation: Cowie, A.T. Forryth, I.A. and I. Hart (1980). Springer-Verlag, Berlin & New York.
14. Mammalian Oviduct: Hafez, E.S., and R.J. Blandu. The University of Chicago Press, Chicago, London.
15. Marshall's Physiology of Reproduction. 4th Edition Vol. 3 Pregnancy and Lactation Part I, II, III edited by G.E. Lamming, Champan and Hall.
16. Patterns of Reproduction: Asdell, S.A. (1964). Constable and Co. London.
17. Practice of fertility control, Choudhary S. K. Churchill and Livingstone.
18. Progress in Reproductive Biology, Vol. 4. The pineal and reproduction: Reiter, R.J. Series Ed. P.O. Hubinant, Karger, Basel. Paris, London (latest edition).
19. Reproduction in Mammals Series: 1 to 6: Austin, C.R. and R. V. Short (1984 & 1994), Cambridge University Press, Cambridge.
20. Shaw's textbook of Gynaecology eds. V. G. Padubidri and S. N. Daftary. 2000.

21. The Biology of Blastocyst: Blandau, R.J. (1971). The University of Chicago Press, Chicago & London.
22. The Prostaglandins Vol. I & II: Ramwell, P.W. (1974). Prenum Press, New York and London.
23. The Testis Vol. 1 to 4: Jhonson, A.D. and W. R., Gomes.
24. Vertebrate Foetal Membrances: Mossman, H.W. (1989). Rutgress Press Ltd.
25. WHO laboratory manual for the examination of human semen and sperm – cervical mucus interaction. 4th Edition Cambridge Univ. Press. 2000.

- **Digestive and Excretory Physiology**

1. Essentials of Human Anatomy and Physiology (12th Edition)-Elaine N. Marieb and Suzanne M. Keller (2018, 2015, 2012) Pearson Education, Inc.
2. Human Physiology, (15th Edition) Stuart Ira Fox and Krista Lee Rompolski, McGraw-Hill Education
3. Medical Physiology, (3rd Edition) (2017) by Elsevier
4. Physiology, (6th Edition) Linda S. Costanzo (2018) Elsevier.
5. Ganong's Review of Medical Physiology (26th Edition) Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks and Jason X.-J. Yuan (2019) McGraw-Hill Education.
6. Guyton and Hall Textbook of Medical Physiology 14th Edition John E. Hall and Michael E. Hall (2021) Elsevier.
7. Guyton and Hall Textbook of Medical Physiology (11th Edition) Arthur C. Guyton and Michael E. Hall (2006) Elsevier.
8. Principles of Anatomy and Physiology (15th Edition) Gerard J. Tortora and Bryan Derrickson (2017) John Wiley and Sons.
9. Principles of Anatomy and Physiology (13th Edition) Gerard J. Tortora and Bryan Derrickson (2012) John Wiley and Sons.
10. Human Physiology-From Cells to Systems (7th Edition) Lauralee Sherwood (2010, 2007) Brooks/Cole, Cengage Learning.
11. Human Physiology-From Cells to systems (4th Canadian edition) Sherwood and Ward (2019) Nelson Education Ltd.
12. Essentials of Medical Physiology (6th Edition) K Sembulingam and Prema Sembulingam (2012) Jaypee Brothers Medical Publishers.
13. CC Chatterjee' s Human Physiology (12th Edition) Vol. I Nitin Ashok John (2018) CBS Publishers and Distributors Pvt. Ltd.
14. CC Chatterjee' s Human Physiology (12th Edition) Vol. II Nitin Ashok John (2018) CBS Publishers and Distributors Pvt. Ltd.
15. Samson Wrights Applied Physiology: Oxford University Press.
16. Comparative Animal Physiology C.L. Prosser, W.B. Saunders and Company.
17. Animal Physiology: Mechanism and Application, R. Eckert, W.H. Freeman and Company.
18. General and Comparative Animal Physiology: W.S. Hoar.
19. Medical Physiology: A Wiley Medical Publication, John Wiley and Sons, New York.
20. A Text Book of General Physiology: Dayson (1964): Little Brown and Co. Boston.
21. Animal Physiology: R. Eckert and D. Randall (1983) 2nd Edn., W.H. Rexeman and Co.

22. Biochemistry and Physiology of the Cell: (2nd Edn.), M.A. Edwards and K.A. Hassall (1980) Mc. Graw Hill Co.

- **General Fish Biology**

1. Fish Physiology Vol. 1 to 13: Hoar H.S. and Randall (Eds.) (1964-1994) Academic press, London, New York.
2. The physiology of fishes Vol. 1and2: Brown M. E. (1957) Academic press, New York.
3. Natural history of fishes and systematic of fresh water fishes:P Datta Munshi, J.S. and Shrivastva, M. P. (1988): Narendra pub. House, Delhi.
4. Air breathing fishes of India- Their structure, function and life history: Dutta Munshi, J. S., Hunghes G.M. (1992). Oxford and JBH publication Co. New Delhi.
5. The freshwater fishes of India, Pakistan, Bangladesh, Burma and Shri Lanka Handbook: Jayaram, K.C. (1981): Zoological Survey of India, Calcutta.
6. Fish migration: Jones, F.R. S. (1968), E.Arnold, London
7. Aquaculture, Bardach, Ryther and Mc Lamy.
8. Marine fisheries: D. K. Dal, K. V. Rao.
9. Ichthyology: Lagler, K. F., Bardach, J. and Miller, R. (1977) John Wileys and sons.
10. Fish Endocrinology: Matty, A. J. (1985), Chapman and Hall, London.
11. An aid to the identification of common commercial fishes of India and Pakistan: Mishra K. S. (1982).
12. Aquaculture: The farming and husbandry of freshwater and marine organism: Bardach, J.E. (1974). Narendra Publication House, New Delhi.
13. Handbook of breeding of Indian Major Carps by pituitary hormone injection: Chonder, S. L. (1970). Satish book enterprises, Agra.
14. Diseases of fish: Duijin, C: Van Inr. (1973), life books London.
15. Fish and fisheries of India: Jhingran, V. G. (1985). Hindustan Publication Company, New Delhi.
16. Prawns and prawn fisheries of India: Kurian, C.V. and Sebastian, V. O. (19876). Hindustan Publication Company, New Delhi.
17. The Sea food Industry: Martin, R. E. (1990). Narendra Publication House, New Delhi.
18. Ecological effects of water, applied limnology and pollutant effect: Welch, E. B. (1992).
19. A compemendium of aquaculture technologies: Sinha, V.R. P. (1993). Oxford and JBH publication Co. New Delhi.

- **General Entomology**

1. Imms General text book of Entomology, Eds. O. W. Richards and R. G. Davis Chapman and Hall, London.
2. General and Applied Entomology, K.K. Nayar, T. N. Ananthkrishan and B.V. Davis Tata McGraw -Hill Co. Ltd. Bombay.
3. The Insect: Structure and function, R.F. Chapman, Cambridge University Press.
4. The Physiology of Insect, Ed. M. Rockstein ,Vol, 1-5, Academic Press, New York.
5. The Physiology of Insect Reproduction, F, Englemann, Pergamon Press, New York.

6. Comprehensive Insect Physiology, Biochemistry and Pharmacology, Eds. G.A. Kerkut and I. A. Gillberd, VOL. 1-13, Pergamon Press, New York.
7. Analytical Biochemistry of Insect, Ed. R. B. Turner, Elsevier, Amsterdam.
8. Insect Hormone, M. J. A. Novak. Chapman and Hall, London.
9. Modern Entomology (Second edition): D. B. Tembhare, Himalaya Publication House, Bombay.
10. Destruction and Useful Insect, Their Hanits and Control, C. L. Metcalf, W. P. Flint and R. I. Metcalf, Mc Grow I Ill Co. New York.
11. Integrated Pest Management, J.L. Apple and R. E. Smith, Plenum Publication Co., New Delhi.
12. An Introduction Of Biological Control RVD Boarscho, P. S. Y. Messenger and A. P. Gaiter, Plenum Publication Co.
13. Text Book of Entomology, K. P. Shivastava, Vol. 1 And 2 Kalyani Publication, Ludhiana.
14. Agriculture Entomology, H. S. Dennis, Timber Press Inc.
15. Entomology and Pest Management, Larry P. Pedigo, Prentice Hall.
16. Text Book of Agriculture Entomology, Alford V. David, Blackwell Science.
17. Biopesticides In Insect Pest Management, S. J. Ignacimulha and Alok Sen, Phoenix Publishing House Pvt, Ltd.
18. Biotechnology in Invertebrate Pathology and Cell culture (Maramorosch, K. ed.). Academic Press, New York.
19. PEBFANS (2003)" (Solomon Raju, A. J. ed.). Andhara University Press, Visakhapatnam.
20. Living Resources for the Millennium 2000 (S. J. William ed.), Students Offset Press, Chennai.

- **Research Methodology**

1. Biostatistics-A foundation for Health Science, Daniel WW, John Wiley (1983).
2. Statistical Methods, Medhi J, Willey Eastern Limited, (1992).
3. Biostatistics-Arora and Malhan
4. Biostatistics- Jasraj and Gurudeep Raj
5. Biostatistics- P. Ramkrishan
6. Methods in Biostatistics-Mahajan
7. https://cpcsea.nic.in/WriteReadData/userfiles/file/SOP_CPCSEA_inner_page.pdf

Semester II

PGZO2T1 Paper-2T1, Structure and Function of Chordates

Course Outcomes (COs)

Students will be able to describe and recognize unique characters, life functions, connecting link between non-chordates and chordates and the diversity of urochordates, cephalochordates, cyclostomes and fish. Describe the structural, physiological and evolutionary correlation of different vertebrates; elaborate how kidneys represented successful evolutionary responses to the surrounding environmental pressures. List some migratory bird species, conduct bird tracking and watching activity. Facilitate students to explore the world of cetaceans and the marine environment. Gain a better understanding of the forces that drive evolution, speciation and the diversity of life on our planet. Identify, describe and differentiate the basic structure and functions of the central and peripheral nervous systems and define learning and memory. Compare and contrast the organization and evolution of the vertebrate circulatory system and heart. Describe specialized sensory organs of vertebrates and relate their role to their habitat. Comprehend the gradual development and evolutionary history of man. Identify, classify, describe and explain vertebrate specimen in the field as well as maintain and organize museum specimen. Develop a skill to demonstrate and explain different anatomical systems of vertebrate, and perform whole mount preparations of given vertebrate materials, different steps of microtomy and staining procedure. They could use, handle and maintain the instruments like microtome and oven. Students will able to identify, demonstrate, explain and compare the histological structure and functions of internal organs of vertebrates.

Semester-II

PGZO2T1 Paper-2T1, Structure and Function of Chordates

UNIT-I

1.1 Origin and ancestry of Chordata.

1.2 Characteristic features and affinities of the Urochordata and Cephalochordata.

1.3 Characteristic features of Agnatha and development of Amoecoetus larva

1.4 General characters and affinities of Dipnoi.

Unit-II

2.1 Organs and mechanism of respiration in Pisces and Amphibia.

2.2 Vertebrate integument and its derivatives.

2.3 Jaw suspension in vertebrates.

2.4 General body organization and classification in Chelonia.

Unit-III

3.1 Evolution of kidney and Excretion in Vertebrates.

3.2 Origin of Birds. Migration in birds.

3.3 Cetacia: general characters and adaptations.

3.4 Adaptive radiation in vertebrates: Aquatic, Terrestrial, Aerial, Arboreal and Fossorial

Unit- IV

4.1 Autonomous nervous system in vertebrates: structure and functions.

4.2 Evolution of Circulatory system and heart in vertebrates.

4.3 Sense organs in vertebrates: Echolocation, Electroreception and Lateral line system in fishes

4.4 Evolution of Man: Oligocene, Miocene, Pliocene primates ancestors of human, Pleistocene hominids: Evolutionary trends in man.

Semester II
PGZO2T2 Paper-2T2, Advanced Developmental Biology

Course Outcomes (COs)

Students will be able to differentiate and explain the basic developmental concept of insects, cast differentiation in insects, amphibian metamorphosis and aves with its hormonal control and regeneration process in vertebrates. Illustrate and classify the type, structure, function and hormones of the placenta, analyse the cell differentiation, organ formation, cell death, and multiple physiological levels of aging. They will be able to analyse the process of advanced cattle breeding with the help of MOET, cloning techniques, acquire knowledge about embryonic sexing to diagnose the genetic disorder, the economic and clinical significance of embryonic stem cells. Comprehend birth control method that uses the body's immune response and classical contraceptive techniques to prevent pregnancy. Explain different anti-androgen and anti-spermiogenic compounds and also discuss transgenic animals that elevated the potential of biological research for human welfare. They will able to demonstrate the development of *Lymnea* and mounting of Chick embryo.

Semester II

PGZO2T2 Paper-2T2, Advanced Developmental Biology

Unit-I

1.1 Basic concepts of Developmental Biology: Model system: *Drosophilla*.

1.2 Basic concepts of Developmental Biology: Model system: Chick.

1.3 Metamorphosis in Amphibia: morphogenetic and biochemical mechanism, hormonal control.

1.4 Placenta-types, structure, functions. Hormones of placenta and their functions.

Unit-II

2.1 Concept of growth, differential cell proliferation, shaping of organ primordia and programmed morphogenetic cell death.

2.2 Ageing- mechanism, concepts and models.

2.3 Polymorphism (caste differentiation) in insect (Termites, Honey bees and Ants).

2.4 Regeneration in vertebrates: tail, limb, lens and retina.

Unit-III

3.1 Multiple ovulation and embryo transfer technology (MOET).

3.2 Application of embryonic stem cells, clinical and economic significance.

3.3 Embryonic sexing, cloning, screening for genetic disorder diagnosis (ICSI, GIFT etc.)

3.4 Cloning of animals by nuclear transfer.

Unit-IV

4.1 Immunocontraception- fertilization, inhibition and pregnancy termination.

4.2 Classical contraceptive techniques: Physical, chemical, surgical and IUCD devices.

4.3 Anti-androgen and anti-spermiogenic compounds (LDH-CY and SP-10)

4.4 Role of mutants and transgenic in human welfare.

Semester-II

PGZO2T3 Paper-2T3, Electives

Course Outcomes (COs)

1. Mammalian Reproductive Endocrinology

Students will be able to comprehend the structural and functional aspect of hypothalamus. Illustrate regulations and feedback mechanism of various neurohormones, neurotransmitters and neural signals, structural and physiological role of pituitary. Elucidate

the histological organization of endocrine glands, gonads and correlate it with the health issues. Describe and explain the non-steroidal regulators of reproduction, the hypothalamic-pituitary axis with the help of gonads, adrenal and thyroid gland, the mechanism of biosynthesis, mode of action and function of reproductive hormones such as estrogen, progesterone, androgen and inhibin that are involved in sexuality and fertility. Prepare, identify, differentiate and explain the histological slides of endocrine gland.

Semester-II

PGZO2T3 Paper-2T3, Electives

1. Mammalian Reproductive Endocrinology

UNIT -I

1.1 Hypothalamus – Anatomy, cytoarchitecture.

1.2 Releasing and release inhibiting hormones.

1.3 Feedback regulatory mechanism

1.4 Neurotransmitters and neural signals.

UNIT -II

2.1 Adenohypophysis and Neurohypophysis- Anatomy, cytology and hormones.

2.2: Non-steroidal regulators of reproduction- Activin and Inhibin, Follistatin, AMH.

2.3 Gonadotrophic hormones: structure, mechanism of secretion and function.

2.4 Oxytocin: Structure, regulation and its role in reproduction.

UNIT -III

3.1 Hypothalamo – hypophyseal testis axis

3.2 Hypothalamo – hypophyseal ovarian axis.

3.3 Hypothalamo- hypophyseal adrenal-gonad axis.

3.4 Hypothalamo – hypophyseal thyroid-gonad axis.

UNIT - IV

4.1 The Androgen: Biosynthesis, mode of action, transport and functions of testosterone.

4.2 The oestrogen: Biosynthesis, mode of action, transport and functions.

4.3 The progesterone: Biosynthesis, mode of action, transport and function.

4.4 Physiology of inhibin: Biosynthesis, mode of action and functions

Semester-II
PGZO2T3 Paper-2T3, Electives
2. Brain and Muscle Physiology

Course Outcomes (COs)

Students will be able to differentiate and classify the various morphological differentiation and analysis of the mammalian brain, brain stem and cerebellum. Elaborate on the physiology and mechanism of learning, memory and sleep. Classify and illustrate the ultrastructure of neurons and synapses, functional and bioelectrical properties of the neurons, molecular mechanism of synaptic transmission and mechanism of neurotropins and growth factors affecting the neuronal growth. Classify and analyse the biosynthesis, storage, release and mechanism of the action of various neurotransmitters and neuropeptides. Differentiate between the structure and physiology of various organs involved in photoreception and phonoreception. Analyse the various causes, symptoms, mechanism of pathogenesis, diagnosis and treatment of neurodegenerative disorders. Explain and describe the classification, ultrastructure, properties and structural proteins of muscle. Illustrate the molecular mechanism of muscular contraction, ultrastructure of the neuromuscular junction and types, causes, symptoms and treatment of various neuromuscular disorders. They could able to demonstrate and estimate liver and muscle glycogen, protein and lipid.

Semester-II
PGZO2T3 Paper-2T3, Electives
2. Brain and Muscle Physiology

UNIT-I

1.1 Morphological differentiation of mammalian brain

1.2 Brain stem

1.3 Cerebellum

1.4 Physiology of learning, memory and sleep

UNIT- II

2.1 Types, ultrastructure and functional properties of neurons

2.2 Ultrastructure of synapse and molecular mechanism of synaptic transmission

2.3 Bioelectrical properties of neurons- neuronal excitability, resting membrane potential- Nearnst equation, sodium and potassium pump, propagation of nerve impulses, generation of action potential.

2.4 Neurotrophins and Growth factor affecting the neuronal growth.

UNIT-III

3.1 Biosynthesis, storage and release of neurotransmitters: Acetylcholine, GABA, Epinephrine, Nor-epinephrine, Serotonin.

3.2 Neuropeptides- oxytocin, vasopression, thyrotropin releasing hormone, cholecystokinin

3.3 Receptor physiology- Photoreception and Phonoreception

3.4 Disorders of nervous system: Alzheimer's disease, Parkinson's disease.

UNIT- IV

4.1 Ultrastructure and Properties of skeletal muscle.

4.2 Molecular mechanism of muscle contraction- muscle proteins, Calcium receptors, Calmodulin, Calcium pump, sliding filament theory, chemistry and role of ATP in muscle contraction

4.3 Ultrastructure of Neuromuscular Junction.

4.4. Neuromuscular Disorders: Types, causes and treatment.

Semester-II
PGZO2T3 Paper-2T3, Electives
3. Economic Aquaculture

Course Outcomes (COs)

Students will be able to describe, explain and compare different water bodies of India, basic techniques used for fish breeding, concepts of fish culture, culture of air breathing fishes, trout fish culture, Ornamental fish culture, integrated fish farming, sewage fed fisheries and cultivation of Indian major carp's. Describe, explain and compare advanced techniques used in aquaculture-based organisms such as pearls, crab, prawn, and oyster.

Semester-II
PGZO2T3 Paper-2T3, Electives
3. Economic Aquaculture

UNIT -I

1.1 Fresh water fisheries of India, Riverine and Reservoir fisheries.

1.2 Estuarine and Marine fisheries of India.

1.3 Breeding of Indian Major carps: i) Natural breeding, ii) Induced breeding, iii) Methods of obtaining fish seed from natural resources.

1.4 Methods of fish cultivation: Intensive and extensive fish cultivation (Pond culture, Cage culture, Pen culture).

UNIT -II

2.1 Culture of Indian major carps and exotic carps (Common carp, Silver carp, Grass carp)

2.2 Monoculture, Monosex culture and Polyculture.

2.3 Integrated Fish farming with– Poultry, Duck, Pig and Paddy.

2.4 Sewage fed fisheries.

UNIT -III

3.1 Culture of air breathing fishes (*Clarias* and *Channa* sp.)

3.2 Trout culture (cultural species, reproduction methods, suitable production condition of trout culture, economics of trout culture)

3.3 Ornamental fish culture: i) Oviparous (gold fish) ii) bubble nest builder (*Betta splendon*) iii) Live bearers (Guppy)

3.4 Culture of sea weeds and Spirulina.

UNIT -IV

4.1 Pearl culture: freshwater and marine pearl oysters, culture methods

4.2 Crab culture (Life cycle, Breeding, culturable species, culture and culture methods)

4.3 Prawn culture (Life cycle, Breeding, culture and culture technology)

4.4 Oyster culture: i) Species-edible ii) Culture methods.

Semester-II
PGZO2T3 Paper-2T3, Electives
4. Insect Morphology and Physiology

Course Outcomes (COs)

Students will able to explain, describe and compare morphology of integument, head, thorax, abdomen, appendages and wings. They could describe, explain and differentiate structure and physiology of systems like digestive, circulatory, respiratory, nervous and neuroendocrine system etc. Students will be able to describe, explain and compare the sensory organs like visual organs, sound and light producing organs, bioluminescence, different mechanoreceptors and chemoreceptors. Describe, explain and compare mechanism of communication, colour change, mimicry and camouflage.

Semester-II
PGZO2T3 Paper-2T3, Electives
4. Insect Morphology and Physiology

UNIT -I

1.1 Integument: molecular structure, moulting and sclerotization.

1.2 Morphology of head, thorax and abdomen.

1.3 Appendages: antennae, legs and genitalia.

1.4 Wing structure and mechanism of flight

UNIT -II

2.1 Mouth parts: type, morphology and feeding mechanism.

2.2 Structure of alimentary canal and salivary glands, mechanism of digestion.

2.3 Respiratory system: tracheal, aquatic and plastron respiratory mechanism.

2.4 Circulatory system: organs, mechanism of circulation, haemolymph –cellular and chemical composition. Functions of haemocytes.

UNIT -III

3.1 Excretory system: organs and physiology of excretion.

3.2 Nervous system: structure and anatomy of brain and ventral nerve cord.

3.3 Neuroendocrine system: structure and function, role in metamorphosis and reproduction.

3.4 Exocrine glands: Pheromones and allomones-chemistry and functions.

UNIT -IV

1.1 Compound eyes, Ocelli and stemmata - structure and functions.

1.2 Sound producing organs: Structure and physiology; Light producing organs: Structure and bioluminescent mechanism.

1.3 Mechanoreceptors: Senseroy hairs, campaniform sensilla and chordotonal organs; Tympanal organs, Johanson's organ, Chemoreceptors- sensilla trichoidea, sensilla basiconica.

1.4 Pigments and mechanism of colour change, mimicry and camouflage.

PGZO2T4 Paper 2T4, On Job Training

Semester-II, PGZO2L1 Skill based practical course in M. Sc. SEM-II Zoology, Structure and Function of Chordates and Endocrinology

1. **Study of museum specimens** using already available specimens in the museum/charts/ models/ photographs/ digital alternatives etc. Classification of vertebrates up to order and comments on the specimens representing all phyla.
2. **Anatomical Observations**
   Anatomical observations, demonstration and detailed explanation of the following with the help of ICT tools/ models/ charts/ photographs etc.
   a) Brain and cranial nerves- Fish/ Rat. b) Arterial and venous systems- Fish/Rat c) Urinogenital system- Fish/Rat. d) Reproductive systems- Fish/Rat. e) Internal ear in fish, Weberian ossicles in fish, accessory respiratory organs in fish.
3. **Mounting:** Study of Stained Permanent preparation of scales, ampullae of Lorenzini, otolith, striated muscles and cartilage of fish using animal wastes from local recognized fish markets or with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
4. **Histology and Skeleton**
   a. Study of slides of internal organs of vertebrates with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
   b. Axial and appendicular skeleton of fowl and rabbit using already available skeleton/ICT tools/ models/ charts/ photographs etc.
5. **Microtomy -** Fixation, embedding, sectioning and staining of the endocrine gland (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry farms/fish markets etc.)
6. **Preparation of histological slides–** a) Histological slide of endocrine glands and gonadal endocrine components, EM structure of endocrine gland. b) Identification of pituitary cell type. c) Identification of α, β, γ, cells of Islets of Langerhans with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
7. **Anatomical Observations-** Anatomical observations, demonstration and detailed explanation of the endocrine glands in a) Cockroach and b) Endocrine glands-

pituitary, thyroid parathyroid, adrenal in fish/rat with the help of ICT tools/ models/ charts/photographs etc.

Distribution of Marks	**Marks**
1. Anatomical observations of fish/rat	15
2. Stained permanent preparation	10
3. Identification and comment on the spots (1-10)	30
4. Submission of stained permanent slides	05
5. Anatomical observations of Endocrine glands	10
6. Histological staining of endocrine gland	10
7. Class Record	10
8. Viva-voce	10

Total Marks	**100**

Semester-II, PGZO2L2 Skill based practical course in M. Sc. SEM-II Zoology, Advanced Developmental Biology and Molecular Biology

1. Study of the reproductive system in mammals with the help of ICT tools/ models/ charts/ photographs etc.
2. Study of different types of eggs on the basis of their yolk content.
3. Study of developmental stages of live eggs of Lymnea or any gastropod with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
4. Study of developmental stages of insects/ fishes with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
5. Study of developmental stages of frog with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
6. Chick Embryo mounting by window method.
7. Study of developmental stages of chick through slides and whole mounts.
8. Morphological study of different types of placenta with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
9. Histological study of placenta with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
10. Sperm count from any domestic animal (Source of semen: Government artificial insemination centre).
11. Demonstration of glycogen/ carbohydrate- PAS reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.).
12. Demonstration of DNA: Feulgen's reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.).
13. Demonstration of DNA: RNA: Methyl Green- Pyronin reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.).
14. Demonstration of Lipid: Sudan Black B staining (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.).
15. Demonstration of Protein: HgBP staining (Source of tissue: Animal wastes from local

recognized slaughter houses/ poultry forms/ fish markets etc.).

16. Histochemical analysis of alkaline phosphatase (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
17. Histochemical analysis of acid phosphatase (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.).
18. Biochemical estimation of sugar: O-toluidine method (Source of blood: Local recognized pathology laboratory)
19. Biochemical estimation of protein: Lowrey's method (Source of blood: Local recognized pathology laboratory)
20. Biochemical estimation of DNA: Diphenylamine method (Source of blood: Local recognized pathology laboratory)
21. Biochemical estimation of RNA: Orcinol method (Source of blood: Local recognized pathology laboratory)
22. To perform tests for qualitative analysis of saliva and bile.
23. Demonstration of separation of amino acids by paper chromatography and TLC.

Distribution of Marks	**Marks**
1. Histochemical demonstration of DNA/RNA protein / carbohydrate/lipids/enzymes	20
2. Estimation of sugar/protein/DNA/RNA/ qualitative analysis of saliva/bile	20
3. Whole mount preparation of chick embryo/sperm count.	15
4. Preparation of development stages of live eggs of *Lymnea*	10
5. Identification and comment on spots (1-5)	15
6. Class record	10
7. Viva voce	10
Total marks	**100**

Suggested Readings

- **Structure and function of Chordates**

1. Alexander R.N., The Chordata, Cambridge University Press London.
2. Barrington EJW, The Biology of Hemichordates and Protochordates, Oliver and Boid Edinberg.
3. Bourne G.H., The structure and function of nervous tissue Academic press New York.
4. Kingslay J.S, Outlines of Comparative anatomy of vertebrates, Central Book Depot, Allahabad.
5. Honyelli A.R. The Chordates Cambridge University Press, London
6. Smith H.S. Evolution of Chordate structure, Hold Rinehart and Wintoin Inc. New York
7. Walter H.A. and Sayles L.D. Biology of Vertebrates Macmillan and co. New York
8. Romer A.S. Vertebrate body W.P. Sanders co., Philadelphia.
9. Young J.Z. Life of Vertebrates Oxford University Press, London.
10. Young J.Z. Life of Mammals Oxford University Press, London.

11. Colbert E.H. Evolution of Vertebrates John Wiley and sons Inc. New York.
12. Kent C.J. Comparative anatomy of Vertebrates.
13. Waterman A.J. Chordate Structure and Functions Macmillan Co. New York.
14. Montagna W. Comparative anatomy clarenden press, Oxford
15. Weichert C.K. Preach W. Elements of Chordates anatomy McGraw-Hill book co., New York.
16. Lovetrup S. The phytogeny of Vertebrates John Wiley and sons Inc., London.
17. Joysey K.A. and Kemp T.S. Vertebrate Evolution Oliver and Boyd, Edinberg.
18. Romer A.S. Vertebrate Paleontology University of Chicago Press, Chicago.
19. Newman Phylum Chordata.
20. Goodrich E.S. Structure and development of vertebrates. Dover publications Inc., New York
21. Hard disty M.W. and Potter I.C. Biology of Lampreys Academic Press Newyork
22. T. B. of Zoology Parker and Haswell W.A. Mac millon co. Ltd. London
23. The Biology of Amphibia Noble G.K. Dover Publication Inc New York.

- ## Advanced Developmental Biology

1. Developmental Biology. 2nd Edition. Leon W. Browwer Saunders College publishing.
2. Current Topics in Developmental Biology eds. R. A. Pedersen and G. P. Schatten.
3. Principles of animal developmental biology: S. C. Goel, Himalaya Publishing House.
4. Developmental Biology, S.F. Gilbert. 4th Edn. Sinauer Associates Inc. Publishers.
5. An Introduction to Developmental Biology: D. A. Ede.
6. Principles of developmental: Paul Weiss edited by Hafner publishing company New York.
7. Cells into organs. 2nd Edition.The forces that shape the Embryo. John Philip Trinkaused. Tom Aloisi.
8. Principles of development: Lewis Wolpert et al. 1998. Oxford University Press.
9. Foundations of Embryology. B. M. Patten and B. M. Carlson. Tata McGraw Hill Publishing Company Ltd., New Delhi.
10. An Introduction to Embryology: Balinsky (1981) 5th Ed. (CBS College Publishing).
11. Embryonic and foetal development. Cambridge University Press by Austin and Short, 1982, 1994 2nd Ed.
12. Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 and 2. Lamming 1984, 2000.

- ## Mammalian Reproductive Endocrinology

1. Comparative Endocrinology and Reproduction. Eds. K.P. Joy, A. Krishna and C. Haldar, Narosa Publishing House (1998).
2. Contraceptive Technology Past, Present and Future: Das. R.P. (1989). N.I.H.F.W. New Delhi.
3. Control of ovulation: Crighton, D.B., Haynes, N.B. Foxcroft, G.R. & G.E. Lamming (1978). Butterworths, London.
4. Encylopedia of Reproduction Vol. I, II, III, IV eds. Ernst Knobil and J.D. Neill (1998).

5. Endocrinology and metabolism. 4th edition 2001. Philip Felig & Lowrence A. Frohmon McGraw Hill Inc. Medical Publishing Division.
6. Endocrinology. Vol. 1 to 3: L.J. Degroot et al. (1989). W.B. Saundors Co. Philadelphia.
7. General Endocrinolgoy: Turner, C.D. & J.T. Bagnara (1990) W.B. Saunders Co., & Toppan Co., Philadelphia, London & Tokyo.
8. Hormonal Control of Lactation: Cowie, A.T. Forryth, I.A. and I. Hart (1980). Springer- Verlag, Berlin & New York.
9. Reproductive Endocrinology: Ref. No. 1, Vol. 3 Hormones in Reproduction
10. The Prostaglandins Vol. I & II: Ramwell, P.W. (1974). Prenum Press, New York and London.

- **Brain and Muscle Physiology**

1. Essentials of Human Anatomy & Physiology (12th Edition)-Elaine N. Marieb and Suzanne M. Keller (2018, 2015, 2012) Pearson Education, Inc.
2. Human Physiology, (15th Edition) Stuart Ira Fox and Krista Lee Rompolski, McGraw-Hill Education
3. Medical Physiology, (3rd Edition) (2017) by Elsevier
4. Physiology, (6th Edition) Linda S. Costanzo (2018) Elsevier.
5. Ganong's Review of Medical Physiology (26th Edition) Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks and Jason X.-J. Yuan (2019) McGraw-Hill Education.
6. Guyton and Hall Textbook of Medical Physiology 14th Edition John E. Hall and Michael E. Hall (2021) Elsevier.
7. Guyton and Hall Textbook of Medical Physiology (11th Edition) Arthur C. Guyton and Michael E. Hall (2006) Elsevier.
8. Principles of Anatomy & Physiology (15th Edition) Gerard J. Tortora and Bryan Derrickson (2017) John Wiley & Sons.
9. Principles of Anatomy & Physiology (13th Edition) Gerard J. Tortora and Bryan Derrickson (2012) John Wiley & Sons.
10. Human Physiology-From Cells to Systems (7th Edition) Lauralee Sherwood (2010, 2007) Brooks/Cole, Cengage Learning.
11. Human Physiology-From Cells to systems (4th Canadian edition) Sherwood and Ward (2019) Nelson Education Ltd.
12. Essentials of Medical Physiology (6th Edition) K Sembulingam and Prema Sembulingam (2012) Jaypee Brothers Medical Publishers.
13. CC Chatterjee' s Human Physiology (12th Edition) Vol. I Nitin Ashok John (2018) CBS Publishers & Distributors Pvt. Ltd.
14. CC Chatterjee' s Human Physiology (12th Edition) Vol. II Nitin Ashok John (2018) CBS Publishers & Distributors Pvt. Ltd.
15. Samson Wrights Applied Physiology: Oxford University Press.
16. Comparative Animal Physiology C.L. Prosser, W.B. Saunders & Company.

17. Animal Physiology: Mechanism & Application, R. Eckert, W.H. Freeman & Company.
18. General & Comparative Animal Physiology: W.S. Hoar.
19. Medical Physiology: A Wiley Medical Publication, John Wiley & Sons, New York.
20. A Text Book of General Physiology: Dayson (1964): Little Brown & Co. Boston.
21. Animal Physiology: R. Eckert & D. Randall (1983) 2nd Edn., W.H. Rexeman &Co.
22. Biochemistry & Physiology of the Cell: (2nd Edn.), M.A. Edwards & K.A. Hassall (1980) Mc. Graw Hill Co.

- **Economic Aquaculture**

1. Fish Physiology Vol. 1 to 13: Hoar H.S. and Randall (Eds.) (1964-1994) Academic press, London, New York.
2. The physiology of fishes Vol. 1and2: Brown M. E. (1957) Academic press, New York.
3. Natural history of fishes and systematic of fresh water fishes:P Datta Munshi, J.S. and Shrivastva, M. P. (1988): Narendra pub. House, Delhi.
4. Air breathing fishes of India- Their structure, function and life history: Dutta Munshi, J. S., Hunghes G.M. (1992). Oxford and JBH publication Co. New Delhi.
5. The freshwater fishes of India, Pakistan, Bangladesh, Burma and Shri Lanka Handbook: Jayaram, K.C. (1981): Zoological Survey of India, Calcutta.
6. Fish migration: Jones, F.R. S. (1968), E.Arnold, London
7. Aquaculture, Bardach, Ryther and Mc Lamy.
8. Marine fisheries: D. K. Dal, K. V. Rao.
9. Ichthyology: Lagler, K. F., Bardach, J. and Miller, R. (1977) John Wileys and sons.
10. Fish Endocrinology: Matty, A. J. (1985), Chapman and Hall, London.
11. An aid to the identification of common commercial fishes of India and Pakistan: Mishra K. S. (1982).
12. Aquaculture: The farming and husbandry of freshwater and marine organism: Bardach, J.E. (1974). Narendra Publication House, New Delhi.
13. Handbook of breeding of Indian Major Carps by pituitary hormone injection: Chonder, S. L. (1970). Satish book enterprises, Agra.
14. Diseases of fish: Duijin, C: Van Inr. (1973), life books London.
15. Fish and fisheries of India: Jhingran, V. G. (1985). Hindustan Publication Company, New Delhi.
16. Prawns and prawn fisheries of India: Kurian, C.V. and Sebastian, V. O. (19876). Hindustan Publication Company, New Delhi.
17. The Sea food Industry: Martin, R. E. (1990). Narendra Publication House, New Delhi.
18. Ecological effects of water, applied limnology and pollutant effect: Welch, E. B. (1992).
19. A compemendium of aquaculture technologies: Sinha, V.R. P. (1993). Oxford and JBH publication Co. New Delhi.

- **Insect Morphology and Physiology**

1. Imms General text book of Entomology, Eds. O. W. Richards and R. G. Davis Chapman and Hall, London.
2. General and Applied Entomology, K.K. Nayar, T. N. Ananthkrishan and B.V. Davis Tata McGraw -Hill Co. Ltd. Bombay.

3. The Insect: Structure and function, R.F. Chapman, Cambridge University Press.
4. The Physiology of Insect, Ed. M. Rockstein, Vol, 1-5, Academic Press, New York.
5. The Physiology of Insect Reproduction, F, Englemann, Pergamon Press, New York.
6. Comprehensive Insect Physiology, Biochemistry and Pharmacology, Eds. G.A. Kerkut and I. A. Gillberd, VOL. 1-13, Pergamon Press, New York.
7. Analytical Biochemistry of Insect, Ed. R. B. Turner, Elsevier, Amsterdam.
8. Insect Hormone, M. J. A. Novak. Chapman and Hall, London.
9. Modern Entomology (Second edition): D. B. Tembhare, Himalaya Publication House, Bombay.
10. Destruction and Useful Insect, Their Hanits and Control, C. L. Metcalf, W. P. Flint and R. I. Metcalf, Mc Grow I Ill Co. New York.
11. Integrated Pest Management, J.L. Apple and R. E. Smith, Plenum Publication Co., New Delhi.
12. An Introduction Of Biological Control RVD Boarscho, P. S. Y. Messenger and A. P. Gaiter, Plenum Publication Co.
13. Text Book of Entomology, K. P. Shivastava, Vol. 1 And 2 Kalyani Publication, Ludhiana.
14. Agriculture Entomology, H. S. Dennis, Timber Press Inc.
15. Entomology and Pest Management, Larry P. Pedigo, Prentice Hall.
16. Text Book of Agriculture Entomology, Alford V. David, Blackwell Science.
17. Biopesticides In Insect Pest Management, S. J. Ignacimulha and Alok Sen, Phoenix Publishing House Pvt, Ltd.
18. Biotechnology in Invertebrate Pathology and Cell culture (Maramorosch, K. ed.). Academic Press, New York.
19. PEBFANS (2003)" (Solomon Raju, A. J. ed.). Andhara University Press, Visakhapatnam.
20. Living Resources for the Millennium 2000 (S. J. William ed.), Students Offset Press, Chennai.

Semester-III

PGZO3T1 Paper-3T1, Parasitology and Immunology

Course Outcomes (COs)

Students will be able to illustrate and differentiate life cycle, mode of transmission, infection and treatment of various bacterial infection and viral infections such as covid, dengue, hepatitis. Describe, explain, classify and differentiate organs of immune system, innate immunity, adaptive immunity, antigen, antibodies, toxin anti-toxin and their cellular target. Demonstrate antigen-antibody interaction with the help of ODD. Illustrate the maturation, activation, differentiation of T and B cell, inheritance of MHC molecules and various pathways of complement system. Classify, describe and differentiate various types of cytokines, hypersensitivity, autoimmunity and immunodeficiency diseases. Explain and describe activation and migration of leucocyte, mast cell, transplantation, tumor immunology, various infectious diseases and vaccines. Illustrate and differentiate working principle and significance of immunotechniques such as RIA and ELISA.

Semester-III

PGZO3T1 Paper-3T1, Parasitology and Immunology

UNIT-I

1.1 Covid 19 and H1N1 viruses- Life cycle, mode of transmission, infection, treatment and awareness programme.

1.2 Dengue and Hepatitis- Life cycle, mode of transmission, infection and treatment.

1.3 *Vibrio cholera* and *Clostridium titani*- Life cycle, mode of transmission, infection and treatment.

1.4 *Yersinia pesties*- Life cycle, mode of transmission, infection and treatment.

UNIT-II

2.1 *Trypanosoma* and *Entomoeba* - Life cycle, mode of transmission, infection and treatment.

2.2 *Leishmania* and Malaria- Life cycle, mode of transmission, infection and treatment.

2.3 *Wuchereria* and *Trichinella* - Life cycle, mode of transmission, infection and treatment.

2.4 Toxins and antitoxins-Types, cellular targets of toxins, application of toxin and antitoxin system.

UNIT-III

3.1 Immune system- innate and adaptive immunity; Antigens and antibodies and its interaction.

3.2 Cells and organs of immune system; T cells and B cells - maturation, activation and differentiation, T cell receptors.

3.3 Major Histocompatibility Complex (MHC) - general organization and inheritance of the MHC, MHC molecules and genes.

3.4 Complement system- classical, alternative and lectin pathways, regulation of complement system, biological consequences of complement activation.

UNIT-IV

4.1 Cytokine- properties, receptors and significance, Leukocyte activation and migration.

4.2 Hypersensitivity reactions- types, hypersensitivity reactions and its diseases; Autoimmunity and its Disease. Immunodeficiency Diseases.

4.3 Transplantation immunology- blood antigens, transplantation or graft rejection, familial grafting, tissue typing, cross matching, and immunosuppression.

4.4 Tumor immunology- Types and roles of tumor antigens, immune response to tumor; Infectious Diseases and Vaccines. Immunotechniques- RIA and ELISA.

Suggested readings

- ## Parasitology

1. Brock Biology of Microorganisms (Ed. IX) M. T. Madigan J. M. Martinko and J. Parker.Prentice Hall International Publication.
2. The Nematode Parasite in Vertebrate, W. Youle and Maplestone.
3. General Parasitology, V. A. Dogiel.
4. Helminthology, E. C. Fausy.

5. Platyhelminthes and Parasitisium, D.R.Birt.
6. Animal Parasite- O.W. Aisen
7. Parasitic Protozoa, J.P. Kreier and J.R. Baker. Allen and Unwin Press.
8. Medical and Veterinary Protozoalogy M. G. Kathering , A. James paul and V. Zaman. Churchill Livingstone.

- **Immunology**

1. Immunology – R. C. Kuby et al.
2. Immunology - Tizzard.
3. Immunology -. Roitt, Brostoff and D. Male.
4. Microbiology- M. T. Pelzer. Jr. E. C. S. Chan and N. R. Krieg. Tata McGraw -Hill
5. Immunology - Abbas

Semester-III

PGZO3T2 Paper-3T2, Wild Life and Avian Biology

Course Outcomes (COs)

Students will explain, describe and analyze importance of wildlife and its conservation, international conservation bodies, predator-prey relationship, population dynamics of ungulates and carnivores. They could also explain, describe and analyze morphology, morphometry of birds, birds diversity, techniques of bird counting, bird breeding population and breeding group maps, bird hotspots, bird sanctuaries and role of birds in ecosystem.

Semester -III

PGZO3T2 Paper-3T2, Wild Life and Avian Biology

UNIT I- Wild life Ecology and Behaviour

1.1 Definition, importance of wildlife, Concept of conservation, Conservation movement in India

1.2 International conservation bodies; IUCN, UNDP, FAO, WWF, Red data book, rare and endangered animals of India.

1.3 Predatory-prey relationship, predator dynamics, optimal foraging theory: patch choice, diet choice, prey selectivity, anti-predator defenses.

1.4 Social organization in carnivores and primates.

UNIT - Wild life Population and Pest Management

2.1 Population estimation of ungulates and carnivores: Faecal samples, Hair identification, Pug marks and census method.

2.2 Management and identification of animals by natural marking, collars, tags, branding, rings etc. Dynamic marking: beta light, radio- tracking, collars.

2.3 Basic Concept of forest soil dwelling arthropods, decomposer food web in forest soil, vertical distribution and aggregation of Collembola and mites.

2.4 Pests of Teak (Borers- *Alcterogystia cadambae* and Defoliators- *Hyblaea puera*) and Sal (Borers- *Hoplocerambyx spinicornis* and Defoliators- *Lymantria mathur*.

UNIT - III- Avian Systematic

3.1 Morphology and morphometry of birds, methods of identification and bird diversity.

3.2 Bird study techniques: equipments, area of study, field data recording, bird photography.

3.3 Bird counting technique: sampling, bird ringing techniques, use of hi-tech gadgets like GPS, CCTV, Camera and high vision equipments.

3.4 Estimation of breeding population, breeding ground mapping.

UNIT - IV- Bird diversity and Breeding

4.1 Bird biodiversity hotspots in India, Bird sanctuaries in India.

4.2 Role of birds in ecosystem – pollination, seed dispersal, insect control, bird migratory routes.

4.3 Breeding biology, nesting territories, bird songs, courtship and mating.

4.4 Types of nest, nest building, nest defense and parental care.

Suggested readings

- ## Wild Life and Avian Biology

1. Ali, S. and Ripley, S. D. 1983. Handbook of the Birds of India and Pakistan Compact Edition. Oxford Univ. Press. New Delhi.
2. Anon. 1975. Forest Pest Control. National academy of Science. NAS, Washington, D. C.
3. Bailey J. A. 1984. Principles of Wildlife Management John Wiley and Son. N.Y.
4. Beeson, C. F. C. 1941. The ecology and control of forest insects of India and neighboring countries, Govt. of India Press.
5. Brockman, O.F. 1959. Recreational use of Wildlife. McGraw Hill Book Company.
6. Daniel, J. C. 1983. The Book of Indian Reptiles, Bombay Natural History Society, Bombay.

7. Davis and Johnson. 1987. Forest Management. McGraw Hill Book Company.

8. Eisenbeis, G and Wichard, W. 1991. Atlas on the Biology of Soil Arthropods, Springer–verlak, London.

9. Elseth, B.D. and Baumgartner, K.M. 2003. Population Biology,Van Nostrand Co., New York.

10. Findley, W. P. K. 1967. Timber pests and diseases: Pregman Press.

11. Graham, S.A. and Knight, F.B. 1965. Principles of Forest Entomology, McGraw Hill book Company.

12. Harris, W.V. 1964. Termites: Their recognition and control. Longmans, London.

13. Krebs, J. R. and Davies, N. B. (1989) An Introduction to Behavioral Ecology. Oxford: Blackwell Scientific Publications.

14. Knight, P. V., 1980. Principles of forest entomology, McGraw Hill Publication.

15. Lenderen D. 1991. Modelling in behavioral ecology. Chapman and Hall London U.K.

16. Rodgers N.A and Panwar H.S 2001. Planning of wild life / Protected area Network in India. The report of wild life Institute of India, Dehradun.

17. Snodgrass, R. E. 1995. Principles of Insect Morphology. USDA.1952. Insects: The Year Book of Agriculture.

18. Staddon, J.E.R. 1983. Foraging and Behavioral Ecology. Adaptive Behavior and

    Learning. Cambridge University Press.

19. Stephens, D.W., Brown, J.S. and Ydenberg, R.C., 2007. Foraging: Behavior and Ecology. Chicago: University of Chicago Press

20. Trippense, R.E. 1953. Wildlife Management, McGraw Hill Book Co.

21. Van Tyne, J. and Berger, A. J., 1976. Fundamental Ornithology, MacMillan Publishing Co. Inc. N. Y.

22. Wallace, G. J. and Mahan H. D., 1975. An Introduction to Ornithology. MacMillan Publishing Co. Inc. N. Y.

23. West, D.C., Shugart, H.H. and Botkin, D.F., 1981, Forest Succession: Concepts and Application, Springer-verlag, New York.

24. Witter, J A and Coulson, R N, 1984, Forest entomology: ecology and management, John Wiley and Sons, U.S.A.

Semester III

PGZO3T3 Paper-3T3, Comparative Endocrinology

Course Outcomes (COs)

Students will be able to identify, classify, differentiate, describe and explain different types of cells and organs of neuroendocrine system of invertebrates. Illustrate the role of hormones in the regulation of various physiological processes in invertebrates such as metamorphosis, reproduction and colour change mechanisms. Describe, explain, and differentiate the hypothalamo-hypophysial system, structure, hormones, functions and feedback mechanisms of pituitary, thyroid, parathyroid, pancreas, gastro-intestinal tract and adrenal gland. Comprehend the role of hormones in pharmaceuticals, including contraception, sex hormones, cancer, immune system and immune regulating hormones (IRH). Raise awareness about the significance of pharmaceutical applications. Students could demonstrate compare the preparation of histological slides of endocrine glands.

Semester-III

PGZO3T3 Paper-3T3, Comparative Endocrinology

Unit-I

1.1 Hormonal control of reproduction in Annelida.

1.2 Neuroendocrine system of Mollusca: Structure and function.

1.3 Neuroendocrine control of reproduction in Mollusca.

1.4 Neuroendocrine control of reproduction in Echinodermata.

Unit-II

2.1 Neuroendocrine system in crustacean; structure and hormones.

2.2 Endocrine control of metamorphosis, reproduction and colour change mechanisms in crustacea.

2.3 Cephalic neuroendocrine system in insects: structure and hormones.

2.4 Endocrine control of metamorphosis and reproduction in insects.

Unit-III

3.1 Pineal organ: Structure, hormones and functions.

3.2 Hypothalamo hypophysial system: Structure, hypothalamic nuclei, hormones and function.

3.3 Pituitary: Cell types, hormones and functions.

3.4 Thyroid and Parathyroid gland: Structure, hormones and functions.

Unit-IV

4.1 Endocrine pancreas and gastro intestinal tract: endocrine cells, hormones and functions.

4.2 Adrenal gland: structure, hormones and functions in vertebrates.

4.3 Gonadal hormones in vertebrates and their hormonal action, feedback mechanisms.

4.4 Hormones as pharmaceuticals- Hormones in contraception, estrogen and cancer, Sex hormones and immune system and immune regulating hormone (IRH).

Suggested readings

- ## Comparative Endocrinology

1. General and Comparative Endocrinology: E.J.W., Barrington, Oxford, Clarendon Press.
2. Text Book of Endocrinology: R.H. Williams, W.B. Saunders.
3. Endocrine Physiology: C.R. Martin, Oxford University Press.
4. Comparative Endocrinology: A Gorbman et al, John Wiley and Sons.
5. Medical Physiology: W.F. Ganong (1981): 10th Edn. Lange Medical Publications.
6. Principles of Anatomy and Physiology: Tortora Grabowski, 9th Edn., John Willey and Sons.
7. Reproductive Physiology of Vertebrates: Van Tienhoven, A. (1983): 2nd Edn. Cornell Univ. Press, New York.
8. The Pituitary Gland: Imura, H. (1994), 2nd Edn., Comprehensive Endocrinology Revised Series Raven, New York.
9. Comparative Vertebrate Endocrinology: Bentley, P.J. (1976) Cambridge University Press, Cambridge.
10. General and Comparative Endocrinology: E.J.W., Barrington, Oxford, Clarendon Press.
11. Text Book of Endocrinology: R.H. Williams, W.B. Saunders.
12. Comparative Vertebrate Endocrinomental: Bentely, P.J. (1976) Cambridge University Press, Cambridge.
13. Invertebrate endocrinology: D. B. Tembhare, Himalaya publishing House (2012).

Semester-III
PGZO3T4 Paper-3T4, Electives
Course Outcomes (COs)
1. Mammalian Reproductive Physiology in Female

Students will be able to understand and evaluate the different processes and hormonal control of ovarian cycle. Describe and specify the mechanism and hormonal control of uterine cycle in different mammalian species. Comprehend the structure, function, regulation, anomalies and disease of female reproductive tract. Discuss the physiological and hormonal reasons behind bodily changes at puberty, the importance of prostaglandins in reproduction. Recognize the anatomical structure and development of breasts, mechanism of synthesis, secretion and ejaculation of milk via hormonal influence. They could detect and confirm the pregnancy by using female urine sample.

Semester-III
PGZO3T4 Paper-3T4, Electives
1. Mammalian Reproductive Physiology in Female

UNIT- I

1.1 Differentiation of the ovary and female genital tract.
1.2 The process of folliculogenesis and its hormonal control.
1.3 Recruitment, selection, dominance of follicle and signaling for ovulation.
1.4 Follicle wall: Theca, differentiation, steroid hormone synthesis (2- gonadotropin,2-cell concept).

UNIT-II

2.1 Estrous cycle in mammals.
2.2 Menstrual cycle and Menopause.
2.3 Mechanism and hormonal control of ovulation.
2.4 Corpus luteum: histogenesis, function, maintenance and luteolysis.

UNIT-III

3.1 Oviduct: structure, regional differentiation and function.
3.2 Uterus: structure, function, types and abnormalities.
3.3 Cervix- structure, function and cervical cancer.
3.4 Vagina-structure, function, detection of various stages of oestrous cycle by vaginal cytology, vaginal plug.

UNIT-IV

4.1 Onset of puberty and delayed puberty.
4.2 Prostaglandins- Structure, biosynthesis, mode of action and their role in reproduction
4.3 Anatomy and growth of mammary glands.
4.4 Lactogenesis and galactopoiesis.

Semester-III PGZO3P1 Skill based practical course in M. Sc. SEM-III Zoology, 1. Mammalian Reproductive Physiology

1. Demonstration of surgical operation in rat/ mice with the help of ICT tools.
   a. Male: Orchidectomy or Vasectomy or Epididymoctomy
   b. Female: Ovariectomy or Hysterectomy or Adrenactomy
2. Anatomical observations, demonstration and detailed explanation of the male and female reproductive system of rat/ mice with the help of ICT tools/ models/ charts/photographs etc.
3. Vaginal smear: Vaginal cytology with relation to estrous cycle with the help of alreadyavailable permanent slides/ ICT tools/ charts/ models/ photographs etc.
4. Pregnancy detection test from urine.
5. Biochemical estimations of fructose/ acid and alkaline phosphatase /sialic acid in reproductive tissue /semen using animal wastes from recognized slaughter houses/ poultry farms/AIC etc.
6. Experimental studies (histological slides for identification) of the following with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
   a. Effects of anti-androgen on testis and sex-accessory glands
   b. Effect of heavy metals on testis and sex accessory glands
   c. Effects of antifertility drugs on ovary and uterus
7. Histology: Preparation of permanent slide of reproductive organs using animal wastes from recognized slaughter houses/ poultry farms.:
   a. Male: Testis, epididymis (caput, carpus and cauda), seminal vesicle and prostate
   b. Female: Ovary, oviduct, uterus, vagina and cervix
8. Study of following endocrine glands with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
   a. Pituitary gland: anatomy, cell types and identification of cell types
   b. Thyroid gland: Histology of active and inactive glands, effects of anti-thyroid drugs
   c. Adrenal: Normal histology and effects of anti-adrenal drugs
9. Embryology: Study of various stages of development of mammalian egg, development of foetal membranes, different types of placenta, progestational changes in uterus with the help of already available permanent slides/ ICT tools/ charts/ models / photographs etc.
10. To study the prenatal stages of human development with the help of already available permanent slides/ ICT tools/ charts/ models/ photographs etc.\
11. Field Work: Visit to Artificial insemination center and Visit to laboratory for embryo transfer and family planning clinics.

Distribution of marks		Marks
1.	Surgical operation	15
2.	Anatomical observations	15
3.	Minor experimental analysis	10
4.	Biochemical estimation	20
5.	Identification and comments on spots (1-5)	15
6.	Submission of permanent slides	05
7.	Practical record	10
8.	Viva-voce	10
	Total Marks	**100**

Suggested Readings

1. Mammalian Reproductive Physiology in Female

1. A textbook of in vitro fertilization and assisted reproduction edited by P.R. Brinsden and P. A. Rainsbur Jaypee brothers 1992.
2. Advances in Reproductive Physiology, Vol. 1 to 6: Mclaren, (1968). Logos Press Ltd., London.
3. Advances in Reproductive Toxicology eds. S. C. Joshi and A. S. Ansari Pointer publishers.
4. Andrology. 2nd Edition Male Reproductive health and dysfunction (Eds. E. Nieschlag & H.M. Behre) 2000.
5. Biochemistry of Mammalian Reproduction: Zanveld, L.J.D. & R.T. Chatterton (1982). John Wiley & sons, New York.The Ovary.Vol. I, II & III: Zuckerman, S, (1962). Academic Press, London.
6. Biology of Gestation: Assalye, N.S. (1968). Academic Press, London.
7. Biology of ovarian follicles in mammals (1985). S. S. Guraya Springer-Verlag.
8. Comparative cellular and molecular biology of testis in vertebrates (Trends in endocrine, paracrine and autocrine regulation of structure of functions) (2001) S.S. Guraya, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta.
9. Comparative Endocrinology and Reproduction. Eds. K.P. Joy, A. Krishna and C. Haldar, Narosa Publishing House (1998).
10. Contraceptive Technology Past, Present and Future: Das. R.P. (1989). N.I.H.F.W. New Delhi.
11. Control of ovulation: Crighton, D.B., Haynes, N.B. Foxcroft, G.R. & G.E. Lamming (1978). Butterworths, London.
12. Encylopedia of Reproduction Vol. I, II, III, IV eds. Ernst Knobil and J.D. Neill (1998).
13. Endocrinology and metabolism. 4th edition 2001. Philip Felig & Lowrence A.

Frohmon McGraw Hill Inc. Medical Publishing Division.
14. Endocrinology. Vol. 1 to 3: L.J. Degroot et al. (1989). W.B. Saundors Co. Philadelphia.
15. General Endocrinolgoy: Turner, C.D. & J.T. Bagnara (1990) W.B. Saunders Co., & Toppan Co., Philadelphia, London & Tokyo.
16. Hormonal Control of Lactation: Cowie, A.T. Forryth, I.A. and I. Hart (1980). Springer- Verlag, Berlin & New York.
17. Mammalian Oviduct: Hafez, E.S., and R.J. Blandu. The University of Chicago Press, Chicago, London.

Semester-III

PGZO3T4 Paper-3T4, Electives

2. Blood and Cardiac Physiology

Course Outcomes (COs)

The students will be able to illustrate the structure, properties and function of cardiac muscle along with the anatomy, histology, nerve innervation and valves of the heart. They will further be able to classify and compare the pacemakers and conducting fibers present in the heart, and illustrate various types, causes, symptoms, diagnosis, and factors affecting blood pressure and treatment. Illustrate and compare the mechanism of the cardiac cycle, heart sound, working principle of ECG, cardiac output, haemodynamic, haemorrhage, cardiac murmur, circulatory shock and cardiac failure. Describe, explain and compare the cellular composition and functions of blood, blood groups, blood transfusion, bone marrow aspiration and pathological conditions of blood glucose and lipids along with blood coagulation. Compare and illustrate the transport of gases by blood, diagnosis, symptoms and treatment of bleeding disorders and blood cancer. Illustrate the mechanism of formation, composition, transport and functions of lymph. Differentiate, describe and explain anaemia and polycythemia, platelets and Blood substitute. Students will be able to demonstrate the components of the blood such as RBCs, WBCs, DLCs, Hb etc. along with the blood group.

Semester-III

PGZO3T4 Paper-3T4, Electives

2. Blood and Cardiac Physiology

UNIT -I

1.1 Structure, properties and function of cardiac muscles.

1.2 Anatomy, histology and nerve innervation of the heart, heart valves.

1.3 Pace maker and specialized conducting fibers.

1.4 Blood pressure- types, causes, symptoms, diagnosis, factors affecting blood pressure and treatment.

UNIT -II

2.1 Cardiac cycle, Electrocardiogram (ECG).

2.2 Cardiac output and its control, heart sound and Cardiac murmur.

2.3. Haemodynamics and Hemorrhage.

2.4 Circulatory shock and cardiac failure.

UNIT -III

3.1 Cellular composition and functions of blood.

3.2 Blood groups and Blood transfusion.

3.3 Anaemia and polycythemia, platelets, Blood substitute and Bone marrow aspiration.

3.4 Pathological condition of blood glucose and lipids diagnosis, symptoms and treatment.

UNIT -IV

4.1 Haemostasis, Cascade of biochemical reactions involved in coagulation of blood.

4.2 Transport of O2 and CO2 by blood.

4.3 Blood disorders- Bleeding disorders and blood cancer, diagnosis, symptoms and treatment.

4.4 Lymph – formation, composition, transport and functions.

Semester-III PGZO3P1 Skill based practical course in M. Sc. SEM-III Zoology, 2. Animal Physiology

I. Physiology Experiments

1. Determination of Clotting time and bleeding time.
2. Determination of Total leukocytes count (TLC).
3. Determination of Total erythrocyte count (TEC).
4. Determination Differential leukocyte count (DLC).
5. Study of structure of RBCs in vertebrates with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
6. Determination of protein, glucose in Urine from normal and diabetic patient.
7. Measuring of heart beat under different physiological condition.

II. Quantitative Analysis

1. Determination of Haemoglobin concentration.
2. Estimation of blood Glucose (Source of blood: Local recognized pathology laboratory).
3. Estimation of blood cholesterol (Source of blood: Local recognized pathology

laboratory).

4. Blood amino-acid separation by TLC / Paper chromatography (Source of blood: local recognized pathology laboratory).
5. Muscle & Liver glycogen (Source of muscle/ liver: Locally recognized fish markets/slaughter houses/ poultry farms etc.).
6. Determination of fructose in seminal vesicle/ semen (Source of semen: Government artificial insemination centre).
7. Estimation of percentage quantity of lactose in milk in vertebrates.

III. Qualitative Analysis

1. Normal and abnormal constituents of human urine.
2. Blood group detection by antisera.
3. Preparation and study of Urine crystals.
4. Preparation and study of haemin crystals.

IV. Histological Study of Stomach, Liver, Small intestine, Large intestine, Pancreas, Kidney, Thyroid, Pituitary, Blood smear, Heart, T.S. Vein, T.S. Artery with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.

Field visit: Visit to National Research Laboratory.

Distribution of Marks:		**Marks**
1.	Physiology Experiment	20
2.	Major quantitative analysis	20
3.	Minor quantitative analysis	10
4.	Qualitative analysis	15
5.	Identification and comment on spots (1-5)	15
6.	Practical Record	10
7.	Viva-voce	10

	Total marks	**100**

Suggested Readings

2. Blood and Cardiac Physiology

1. Essentials of Human Anatomy & Physiology (12th Edition)-Elaine N. Marieb and Suzanne M. Keller (2018, 2015, 2012) Pearson Education, Inc.
2. Human Physiology, (15th Edition) Stuart Ira Fox and Krista Lee Rompolski, McGraw-Hill Education
3. Medical Physiology, (3rd Edition) (2017) by Elsevier
4. Physiology, (6th Edition) Linda S. Costanzo (2018) Elsevier.

5. Ganong's Review of Medical Physiology (26th Edition) Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks and Jason X.-J. Yuan (2019) McGraw-Hill Education.
6. Guyton and Hall Textbook of Medical Physiology 14th Edition John E. Hall and Michael E. Hall (2021) Elsevier.
7. Guyton and Hall Textbook of Medical Physiology (11th Edition) Arthur C. Guyton and Michael E. Hall (2006) Elsevier.
8. Principles of Anatomy & Physiology (15th Edition) Gerard J. Tortora and Bryan Derrickson (2017) John Wiley & Sons.
9. Principles of Anatomy & Physiology (13th Edition) Gerard J. Tortora and Bryan Derrickson (2012) John Wiley & Sons.
10. Human Physiology-From Cells to Systems (7th Edition) Lauralee Sherwood (2010, 2007) Brooks/Cole, Cengage Learning.
11. Human Physiology-From Cells to systems (4th Canadian edition) Sherwood and Ward (2019) Nelson Education Ltd.
12. Essentials of Medical Physiology (6th Edition) K Sembulingam and Prema Sembulingam (2012) Jaypee Brothers Medical Publishers.
13. CC Chatterjee' s Human Physiology (12th Edition) Vol. I Nitin Ashok John (2018) CBS Publishers & Distributors Pvt. Ltd.
14. CC Chatterjee' s Human Physiology (12th Edition) Vol. II Nitin Ashok John (2018) CBS Publishers & Distributors Pvt. Ltd.
15. Samson Wrights Applied Physiology: Oxford University Press.
16. Comparative Animal Physiology C.L. Prosser, W.B. Saunders & Company.

Semester-III

PGZO3T4 Paper-3T4, Electives

3. Fish Physiology

Course Outcomes (COs)

Students will be able to describe, explain and compare structure and physiology of associated system like digestive, sensory organs, osmoregulation, nervous system and reproductive system of teleost. They could explain and describe different mode of migration in fishes with respect to periodicity and role of hormones. They could also explain, describe and analyse hormonal control via hypothalamo-hypophysial system and neuroendocrine system of gametogenesis and reproductive behavior in fishes. Students could also able to demonstrate and explain ablation of gonad in fishes.

Semester-III

PGZO3T4 Paper-3T4, Electives

3. Fish Physiology

UNIT -I

1.1 Structure of alimentary canal in teleosts; feeding habits, histology of (Oesophagus, Stomach, Small intestine, Large intestine, Rectum)
1.2 Modification of alimentary canal in relation to feeding habits, digestion and absorption of Food.
1.3 Excretion: Structure of kidney in teleosts (Head kidney and trunk kidney, histology of kidney and blood supply)
1.4 Osmoregulation in Freshwater forms, Marine forms, Rays and Skates, Diadromous fishes.

UNIT -II

2.1 Chemoreceptors: Structure of olfactory system, morphology of peripheral olfactory organ, cellular composition of olfactory epithelium, olfactory bulb and central projections.
2.2 Electric organs of fishes
2.3 Brain and cranial nerves of fishes.
2.4 Migration in fishes: Types- Anadromous, Catadromous, Amphidromous, factors responsible for migration, periodicity of migration, Role of hormones in migration.

UNIT-III

3.1 Structure of male reproductive system
3.2 Mechanism of spermatogenesis and its hormonal control
3.3 Structure of female reproductive system
3.4 Oogenesis, egg development, hormonal control of oogenesis

UNIT-IV

4.1 Structure, hormones and functions of pituitary gland in fishes
4.2 Structure, hormones and functions of other endocrine glands.
4.3 Structure of Hypothalamo-hypophysial system in fishes.
4.4 Neurohormones and their functions.

Semester-III PGZO3P1 Skill based practical course in M. Sc. SEM-III Zoology, 3. Fish and Fisheries

1. Identification of commercially important fishes up to species.
2. Anatomical observations, demonstration and detailed explanation of general anatomy of fish, urinogenital system and endocrine glands with the help of ICT tools/ models/ charts/ photographs etc.
3. Study of cranial nerves in *Wallago* and *Labeo* with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.

4. Elementary work on surgical ablation with reference to gonads with the help of ICT tools/ charts/ models / photographs etc.
5. Study of RBC count in fish blood (Source of fish blood: Locally recognized fish markets)
6. Study of WBC count in fish blood (Source of fish blood: Locally recognized fish markets)
7. Study of permanent histological slides of various fish organs & endocrine glands with the help of already available permanent slides/ ICT tools/ charts/ models/ photographs etc.
8. Study of skeletal system of *Wallago* & *Labeo* with the help of already available skeleton/ ICT tools/ charts/ models / photographs etc.
9. Estimation of dissolve oxygen in water sample.
10. Estimation of CO2 in water sample.
11. Permanent mounting of zooplankton.
12. Permanent preparation of various scales using wastes from Locally recognized fish markets.
13. Visit to fish farm/ breeding centre.

Distribution of Marks	**Marks**
1. Anatomical observations (Major)	15
2. Physiology Experiment	20
3. Mounting of Scale	10
4. Identification of fishes	30
5. Practical Record	10
6. Viva voce	10
7. Submission of Tour diary	05

Total marks	**100**

Suggested readings

3. Fish Physiology

1. Fish Physiology Vol. 1 to 13: Hoar H.S. and Randall (Eds.) (1964-1994) Academic press, London, New York.
2. The physiology of fishes Vol. 1and2: Brown M. E. (1957) Academic press, New York.
3. Natural history of fishes and systematic of fresh water fishes:P Datta Munshi, J.S. and Shrivastva, M. P. (1988): Narendra pub. House, Delhi.
4. Air breathing fishes of India- Their structure, function and life history: Dutta Munshi, J. S., Hunghes G.M. (1992). Oxford and JBH publication Co. New Delhi.
5. The freshwater fishes of India, Pakistan, Bangladesh, Burma and Shri Lanka Handbook: Jayaram, K.C. (1981): Zoological Survey of India, Calcutta.
6. Fish migration: Jones, F.R. S. (1968), E.Arnold, London
7. Aquaculture, Bardach, Ryther and Mc Lamy.
8. Marine fisheries: D. K. Dal, K. V. Rao.

9. Ichthyology: Lagler, K. F., Bardach, J. and Miller, R. (1977) John Wileys and sons.
10. Fish Endocrinology: Matty, A. J. (1985), Chapman and Hall, London.
11. An aid to the identification of common commercial fishes of India and Pakistan: Mishra K. S. (1982).
12. Aquaculture: The farming and husbandry of freshwater and marine organism: Bardach, J.E. (1974). Narendra Publication House, New Delhi.
13. Handbook of breeding of Indian Major Carps by pituitary hormone injection: Chonder, S. L. (1970). Satish book enterprises, Agra.
14. Diseases of fish: Duijin, C: Van Inr. (1973), life books London.
15. Fish and fisheries of India: Jhingran, V. G. (1985). Hindustan Publication Company, New Delhi.
16. Prawns and prawn fisheries of India: Kurian, C.V. and Sebastian, V. O. (19876). Hindustan Publication Company, New Delhi.
17. The Sea food Industry: Martin, R. E. (1990). Narendra Publication House, New Delhi.
18. Ecological effects of water, applied limnology and pollutant effect: Welch, E. B. (1992).
19. A compemendium of aquaculture technologies: Sinha, V.R. P. (1993). Oxford and JBH publication Co. New Delhi.

Semester-III

PGZO3T4 Paper-3T4, Electives

4. Insect Pest Management

Course Outcomes (COs)

Students will study about life cycle, host plants, damage and control measures of various insect-pests of field crops. Identify common insects and insect pest of different orders available in local area and could form local or regional insect diversity register as well as demonstrate different pathogen in insect tissues. Students will be able to illustrate and compare the properties, mode of action and uses of inorganic insecticide, chlorinated hydrocarbons, organophosphates and botanical insecticides. Explain and describe biological control measure, nano-biopesticide. pathogenic viruses, bacteria, parasitoids and predators of insect pests. Describe various techniques used in pest control programmes such as use of radiation, chemosterilants, hormones and pheromones.

Semester-III

PGZO3T4 Paper-3T4, Electives

4. Insect Pest Management

UNIT -I

1.1 Pest of major crops: Rice, Cotton and Sugarcane-classification, life history, damage and control.
1.2 Pest of fruits: Citrus and Mango-classification, life history, damage and control.
1.3 Pest of vegetables: Cabbage and Brinjal- classification, life history, damage and control.
1.4 Stored grain pests: Classification, life history, damage and control measures.

UNIT -II

2.1 Inorganic insecticides: Properties, mode of action and use.
2.2 Chlorinated Hydrocarbons: Properties, mode of action and use.
2.3 Organophosphates: Properties, mode of action and use.
2.4 Natural organic compound and pyrethroids: Properties, mode of action and use.

UNIT-III

3.1 Biological control: Historical and theoretical basis of biological control and Desirable attributes of natural enemies of pests.
3.2 Parasitoids used in biological control programmes: life cycle and biological relationship.
3.3 Predators used in biological control programmes: life cycle and biological relationship.
3.4 Nano bio pesticides: Properties, mode of action and use.

UNIT-IV

4.1 Insect pathogenic bacteria used in biological control programmes, biological relationship, mass production and examples.
4.2 Insect pathogenic viruses used in biological control programmes, biological relationship, mass production and examples
4.3 Use of radiation, chemosterilants, hormones and pheromones in pest control programmes.
4.4 Integrated pest managements: principles, modeling, application and examples.

Semester-III PGZO3P1 Skill based practical course in M. Sc. SEM-III Zoology, 4. Entomology

1. Anatomical observations, demonstration and detailed explanation of the various organs and systems in insects such as silk gland in silkworm, cockroach, grasshopper, cricket, molecricket, red cotton bug, honey bee, house fly, butterfly/ moth and caterpillars with the help of ICT tools/ models/ charts/ photographs etc.
2. Histological study of alimentary canal, salivary glands, silk gland, malpighian tubules, testis, ovary, sex accessory glands, exocrine glands, endocrine glands and brain with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.

3. Whole mount preparation of insect parts using insects from agricultural wastes or with the help of already available permanent slides/ ICT tools/ charts/ photographs/ models etc.
4. Insect study- Identification, classification and characters up to families belonging to orders- Odonata, Orthoptera, Dictyoptera, Hemiptera, Lepidoptera, Coleoptera, Hymenoptera, Diptera etc. with the help of already available museum specimens, permanent slides/ ICT tools/ charts/ photographs/ models etc.

5. **Physiological Experiments:**

   a. Estimation of total proteins/carbohydrates/lipids
   b. Estimation of DNA and RNA.
   c. Chromatographic separation of free amino acids
   d. Separation of proteins by electrophoresis

6. Preparation of photographic life history of economical important insects.
7. Preparation of insect biodiversity register of a specific area by photographic collection/ observation.
8. Visit to agricultural fields, national parks, Apiculture, Sericulture, Lac culture centers and entomology research laboratory/center.

Distribution of Marks	**Marks**
1. Anatomical observations	15
2. Physiological Experiment	10
3. Identification of histological slides and insects (1-15)	45
4. Mounting	05
5. Class records	10
6. Submission of insect photographs	05
7. Viva-voce	10
Total marks	**100**

Suggested readings

4. Entomology

1. Imms General text book of Entomology, Eds. O. W. Richards and R. G. Davis Chapman and Hall, London.
2. General and Applied Entomology, K.K. Nayar, T. N. Ananthkrishan and B.V. Davis Tata McGraw -Hill Co.Ltd. Bombay.
3. The Insect: Structure and function, R.F. Chapman, Cambridge University Press.
4. The Physiology of Insect , Ed. M.Rockstein ,Vol, 1-5, Academic Press, New York.
5. The Physiology of Insect Reproduction, F, Englemann, Pergamon Press, New York.
6. Comprehensive Insect Physiology , Biochemistry and Pharmocology , Eds. G.A. Kerkut and I. A. Gillberd, VOL. 1-13, Pergamon Press, New York.
7. Analytical Biochemistry of Insect, Ed. R. B. Turner, Elsevier, Amsterdam.
8. Insect Hormone, M. J. A. Novak. Chapman and Hall, London.
9. Modern Entomology(Second edition): D. B. Tembhare, Himalaya Publication House, Bombay.

10. Destruction and Useful Insect, Their Hanits and Control, C. L. Metcalf, W. P. Flint and R. I. Metcalf, Mc Grow I Ill Co. New York.
11. Integrated Pest Management, J.L. Apple and R. E. Smith, Plenum Publication Co., New Delhi.
12. An Introduction Of Biological Control RVD Boarscho, P. S. Y. Messenger and A. P. Gaiter, Plenum Publication Co.
13. Text Book of Entomology, K. P. Shivastava, Vol. 1 And 2 Kalyani Publication, Ludhiana.
14. Agriculture Entomology, H. S. Dennis, Timber Press Inc.
15. Entomology and Pest Management, Larry P. Pedigo, Prentice Hall.
16. Text Book of Agriculture Entomology, Alford V. David, Blackwell Science.
17. Biopesticides In Insect Pest Management, S. J. Ignacimulha and Alok Sen , Phoenix Publishing House Pvt, Ltd.
18. Biotechnology in Invertebrate Pathology and Cell culture (Maramorosch, K. ed.). Academic Press, New York.
19. PEBFANS (2003)" (Solomon Raju, A. J. ed.). Andhara University Press, Visakhapatnam.
20. Living Resources for the Millennium 2000 (S. J. William ed.), Students Offset Press, Chennai.

PGZO3P2, Research Project (RP) Minor Work
Course Outcomes (COs)

After completion of minor research project, the student will able to search research articles online and offline. Draft scientific write up and submit in the form of report. They will able to check the script for plagiarism. Discuss particular topic and could arrange it in a proper manner. Learn and write bibliography by various styles.

PGZO3P2, Research Project (RP) Minor Work

In this minor research project, the student shall be required to carry out exhaustive literature survey and prepare a review covering a literature survey of last 20 years in the area specific to students/supervisors chosen research area and prepared review has to be checked for plagiarism with the plagiarism policy of University. The evaluation of this minor project will be done at departmental level by the approved internal and external examiners.

Semester-IV

PGZO4T1 Paper-4T1, Biotechniques, Biostatistics, Ethology, Toxicology and Bioinformatics

Course Outcomes (COs)

Students will be able to elaborate, discuss and describe sterilization, animal cells, tissue culture, primary culture, cell lines, cell quantification, and growth kinetics and cryopreservation technique. Describe, demonstrate and explain the principle and working mechanism of sedimentation, centrifugation, TLC, gas chromatography and electrophoretic technique. Illustrate and explain the biostatistical measures such as central tendency, dispersion, probability, sampling types, methods and significance test. Describe and explain neuronal genetics, environmental components in the development of animal behaviour, organization and functions of animal ethics. Illustrate and explain about the significance of toxicity test in the projects and research. Describe and explain the importance and scope of bioinformatics, various biological databases such as BLAST and FASTA, PSI- BLAST etc. and various program runs for the construction of phylogenetic tree like MEGA. Students could construct, analyze and interpret phylogenetic tree.

Semester-IV

PGZO4T1 Paper-4T1, Biotechniques, Biostatistics, Ethology, Toxicology and Bioinformatics

UNIT- I

1.1 Sterilization techniques, media for microbial culture, inoculation methods
1.2 Animal cell & tissue culture- primary culture, cell lines, cell quantification, growth kinetics of cells in culture, cryopreservation of cells
1.3 Basic principle of sedimentation and centrifugation; Radioactive isotopes.
1.4 Chromatographic separation- Thin layer and gas chromatography; Electrophoretic separation techniques.

UNIT - II

2.1 Central tendency and dispersion- mean, mode and median with examples; Dispersion and variance.
2.2 Probability and probability distribution -Basic theory and type of probability and probability distribution with example (binomial, poison and normal distribution).
2.3 Sampling – types, standard error (SE), standard deviation (SD), significance tests - t-test, z- test, Chi square test- assumption, importance and example.
2.4 Neuronal control, genetic and environmental components in development of animal behavior; Animal ethics- Introduction, concept, organizations and their functions.

UNIT - III

3.1 Introduction and scope of toxicology

3.2 Environmental toxicology- Classification of environmental toxicants; Pesticides, Fertilizers, Heavy and trace metals, radioactive substances, food additives, automobile emission.

3.3 Translocation of toxicants- absorption, distribution, biotransformation and excretion of toxicants

3.4 Toxicity tests- Types (Acute and Chronic), calculation of LC50 and LD 50; Antidotal therapy- Antidotes, type of antidotes and antidotal procedure.

UNIT - IV

4.1 Introduction and scope of bioinformatics - history, scope of bioinformatics in research, business and employment opportunities; Bioinformatics in India.

4.2 Sequence alignment- Pair wise sequence alignment and multiple sequence alignment program CLUSTAL ω and CLUSTAL W.

4.3 Biological databases– History of Basic local alignment search tool (BLAST), and FASTA, Variants of BLAST, PSI-BLAST.

4.4 Phylogenetic analysis- Tree style (Monophyletic, Paraphyletic and Polyphyletic) tree building algorithm (Neighbor joining, Maximum livelihood and Maximum parsimony), Phylogenetic tree construction using MEGA.

Suggested reading

- ## Tissue culture and Biotechniques

1. Animal cell culture – A practical approach, (III Edition) Ed. John R. W. Masters. IRLPress.
2. *In vtro*-cultivation of animal cell, biotechnology by open learning (BIOTOL), Butterworth Heinemann Ltd. Linaere house, Jordan Hill Oxford.
3. Introduction to instrumental analysis, Robert Broun, McGraw Hill International Edition.
4. A Biologist Guide to Principle and Techniques of Practical Biochemistry K. Wilson and K.H. Goulding ELBS Edition.
5. Molecular Cell Biology, J. Darnel, H. Lodish and D. Baltimore. W. H. Freeman and Company New York.
6. DNA Techniques by Alcamo.
7. Insect Cell Culturing Engineering, Ed. M. F. A. Goosen, A.J. Daugulis and P.Faulkner.
8. Biotechnlogy - B. D. Sings.
9. Biophysical Chemistry – Upadhyay, Upadhyay and Nath.

- ## Toxicology

1. Animal Clinical Chemistry: A Primer for Toxicologists. G.O. Evans (Ed.) ISBN: 0748403515, Taylor & Francis, 1996.
2. Animal Models in Toxicology. S.C. Gad & C.P. Chengelis (Eds.), ISBN: 0824784561, Marcel Deker, 1992.
3. Annual Reviews of Pharmacology & Toxicology, ISBN: 0824304373, 1997
4. Basic Toxicology: Fundamentals, Target Organ & Risk Assessment. F.C. Lu, ISBN:

1560323809, Taylor & Francis, 1996.
5. Casarett & Doull's Toxicology: The Basic Science of Poisons. C.D. Klaassen (Ed), ISBN: 0071054766, McGraw-Hill, 1996.
6. Comprehensive Toxicology. I. Sipes, C.A. McQueen & A. Gandolfi (Eds.), ISBN: 0080423019, Elsevier Science, 1997.
7. General & Applied Toxicology. B. Ballantyne, T. Mars & P. Turner (Eds), Vol I & II, ISBN: 0333498011, Macmillon/Stockton Press, 1993.
8. Loomi's Essentials of Toxicology, T.A. Loomis & A.W. Hayes, ISBN: 0124556256, Academic Pess, 1996.
9. Encyclopaedia of Toxicology, Chemical and Concepts, P. Wexler, ISBN: 012227220-X, Academic Press, 1998.
10. Dictionary of Toxicology. E. Hogson, J.E. Chambers & R.B. Mailman, ISBN:1561592161, Groves ic, 1997.

- **Biostatistics**

1. Biostatistics-Arora and Malhan
2. Biostatistics- Jasraj and Gurudeep Raj
3. Biostatistics- P. Ramkrishan
4. Methods in Biostatistics-Mahajan

- **Bioinformatics**

1. Mount W. 2004. Bioinformatics and sequence genome analysis 2nd Editon CBS Pub. New Delhi.
2. Bergman, N. H. Comparative Genomics. Humana Press Inc. Part of Springer Science+BusinessMedia, 2007.
3. Baxevanis, A. D. Ouellate, B. F. F. 2009. Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
4. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings.
5. Des Higgins and Willie Taylor 2000. Bioinformatics: Sequence, structure and databanks. Oxford University Press.
6. Rashidi H. H. and Buehler 2002. Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London.
7. Gibas Cynthia and Jambeck P. 2001. Developing Bioinformatics Computer Skills: Shroff Publishers and Distributors Pvt. Ltd. (O'Reilly), Mumbai.

Semester-IV

PGZO4T2 Paper- 4T2, Radiation and Chronobiology

Course Outcomes (COs)

The students will be able to define and explain the scope and significance of radiobiological scope in human welfare. Identify ionizing radiation, linear energy transfer, radiation dose and units and conceptualize the radiation types. Describe, explain and analyze application of radiology and gainful and harmful effects of radiation. Comprehend the concept of circadian rhythm, central clock system and peripheral clock system. Students will describe, explain and analyze centers of biological clock, relevance of biological clock in

human welfare, mechanism of regulation of biological clock and effects of irregularity of biological clock and its remedies.

Semester –IV

PGZO4T2 Paper- 4T2, Radiation and Chronobiology

Unit- I: Radiation Biology

1.1 Definition, scope and significance of radiation biology.
1.2 General classification ofradiation. Ionizing radiation, linear energy transfer, radiation dose and units.
1.3 Principles of radiation dosimetry, direct and indirect effects. Radiations lesions in DNA, radiobiological effect on cell.
1.4 Radiation sensitizers and protectors.

Unit II: Effect of Radiation on Human Health

2.1 Health consequences after total body irradiation from radiation accidents.
2.2 Long term radiation risks from low radiations doses.
2.3 Radiation induced cancer.
2.4 Radiation effects in the developing embryo and fetus, radiation induced heritable diseases.

Unit- III: Circadian cycle

3.1 Organization of circadian system in multicellular animals.
3.2 Concept of central and peripheral clock system.
3.3 Circadian pacemaker system in invertebrates with particular reference to *Drosophila.*
3.4 Circadian pacemaker system with particular reference to rodents.

Unit- IV: Biological clock

4.1 Chronobiology- Introduction, Centers of biological clock – Supra chiasmatic nuclei, pineal gland and optic lobes.
4.2 The relevance of biological clock for human welfare- clock function and dysfunction.
4.3 Depression and sleep disorders.
4.4 Chronopharmacology, chronomedicine, chronotherapy.

Suggested readings

- **Radiation and Chronobiology**

1. Kumar, V. 2002. Biological Rhythms, Narosa Publishing House, Delhi/ Springer-Verlag, Germany
2. Dunlap, J. C., Loros, J. J. & DeCoursey, P. J. 2004. Chronobiology Biological Timekeeping, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
3. Fliedner, T. M., Friesecke, I. & Beyrer, K., 2001. Medical management of radiation accidents– manual on the acute radiation syndrome.British Institute of Radiology Supplement.
4. Kramer, K. & Merrow, G. 2013. Handbook of Experimental Pharmacology, Circadian Clocks, Springer, London.

5. Hall, E. J, Giaccia A. J. 2006. Radiobiology for the radiologist, Philadelphia, Pa: Lippincott Williams & Wilkins.
6. Saunders, D.S., Steel, C.G.H., Afopoulou X. & Lewis, R.D. 2002. Insect Clocks, Barens and Noble Inc., New York, USA.
7. International Commission on Radiological Protection, 2003: Biological effects after prenatal irradiation (embryo and foetus), ICRP publication.
8. International Commission on Radiological Protection, 2006: Low dose extrapolation of radiation-related cancer risk, ICRP publication.
9. Foster, R. & Kreitzman, L. 2014. Rhythms of Life, The Biological Clocks that Control the Daily Lives of Every Living Thing by, Profile Books Ltd.

Semester IV

PGZO4T3 Paper-4T3, Molecular Biology and Biotechnology

Course Outcomes (COs)

Students will be able to analyse the basics of cellular genome, organization of genetic material, fundamental process of duplication of genetic material in prokaryotes and eukaryotes important for cell division. Evaluate the different types of DNA damage and repair mechanism. Illustrate the fundamentals of various mobile DNA elements useful in horizontal gene transfer, evolutionary process and gene expression in prokaryotes and eukaryotes. Explain the mechanisms and regulation of operon models significant in regulation of gene expression in prokaryotes. Illustrate the fundamental process of protein synthesis with explanation of antisense and ribozyme technology. They could differentiate and distinguish DNA sequencing and gene amplification methods, cloning by different cloning vectors for recombinant DNA technology. Explain and describe the applications of molecular biology and biotechnology. They could demonstrate and estimate DNA, RNA, Protein and Carbohydrates.

Semester-IV

PGZO4T3 Paper-4T3, Molecular Biology and Biotechnology

Unit-I

1.1 Structure and organization of cellular genome - C-value paradox and Cot ½ value. Structure of chromosome. Organization of chromatin fiber (Nucleosome, solenoid model, histones, nonhistones). Forms of DNA.

1.2 DNA replication – Molecular mechanisms of prokaryotic and eukaryotic DNA replication. Structure and role of prokaryotic and eukaryotic DNA polymerase. Regulation of replication.

1.3 DNA damage – Types of DNA damage, causes and various causative agents. Repair of DNA damage – Mismatched repair. Excision repair. Recombination repair. Double strand break repair. transcription coupled repair

1.4 Mobile DNA elements – Transposable elements in bacteria. IS elements. Composite transposons. Bacteriophage Mu transposition. Tn 10 transposition. SINES and LINES. Retroviruses and retroposons.

Unit-II

2.1 Transcription- prokaryotic and eukaryotic transcription, RNA polymerases, transcriptional unit, initiation, elongation, termination, transcriptional factors. Post transcription modifications.

2.2 Regulation of gene expression- Regulatory proteins (Helix turn helix, zinc finger, homeodomain, leucine zipper). Regulation of gene expression in Prokaryotes – Lac Operon model, positive and negative control, Tryptophan operon model. Tryptophan attenuator.

2.3 Regulation of gene expression in eukaryotes- Transcriptional activators. Transcriptional repressors. Direct and indirect repression. Post-transcriptional gene regulation by RNA interference.

2.4 Translation- Prokaryotic and eukaryotic translation. Altered code in elongation. Termination factors. Fidelity of translation. Post translational modifications.

Unit-III

3.1 Antisense and ribozyme technology – inhibition of splicing, polyadenylation, molecular mechanisms of antisense molecules, miRNA, siRNA, gene silencing.

3.2 Isolation and sequencing techniques- Isolation and sequencing of DNA, gene amplification, PCR, RAPD, RFLP, Maxam Gilbert, Sanger's dideoxy methods.

3.3 Splicing and Cloning – Cloning vectors for recombinant DNA technology- plasmids, cosmids, phagemids, YACS, gene replacement, restriction enzymes.

3.4 Hybridization techniques – Southern- Northern hybridization. Microarray.

Unit-IV

4.1 Medical Biotechnology-Application of restriction fragment length polymorphism (RFLP) in forensic science, disease prognosis and genetic counselling.

4.2 Agricultural biotechnology- Biofertilizers. Bioinsecticides. Biogas. Genetically modified (GM) crop.

4.3 Immunobiotechnology-Hybridoma technology, Fluorescent In situ hybridization (FISH), Genome In situ hybridization (GISH).

4.4 Industrial and Environmental biotechnology-microbial production of fermentation products, enzymes, antibiotics, single Cell proteins and biosensors.

Suggested readings

- ## Molecular Biology and Biotechnology

1. Harper's Review of Biochemistry, Prentice Hall.
2. Principles of Biochemistry by Lehninger and Nelson, CBS publications and Distributors.
3. The Biochemistry "Students companion" by Allen J. Scism, Prentice Hall.
4. Fundamentals of Biochemistry by Jain J. L., S. Chand Publication.
5. Principles of Biochemistry by Zubay J. L., WM. C. Brown Publishers.
6. Principles of Biochemistry by Horton, Prentice Hall.
7. Concept of Biochemistry by Boyer R., Coel publication co.

8. Harper's Biochemistry eds.Murray, R. K. P. and Granner, D. K. Prentice Hall.
9. Biochemistry by Mathews C. K. and Van Holde K. E., Benjamin C. publishing Co.
10. Biochemistry by Garrett R. H. and Grisham C. M., Saunders College publication.
11. Cell and Molecular Biology by De Robertis- E. D. P., I. S. E. publication.
12. Molecular Biology by Turner P. C. and Mc Lennan , Viva Books Pvt. Ltd.
13. Advanced Molecular Biology by Twyman R. M., Viva Books Pvt. Ltd.
14. Molecular Biology by Freifelder D., narosa publication House.
15. Gene VI by Benjamin Lewis, Oxford press.
16. Gene VIII by Benjamin Lewis, Oxford press.
17. Molecular biology of Gene by Watson J. D. et. al., Benjamin publication.
18. Molecular cell Biology by Darnell J. Scientific American Books USA.
19. Molecular Biology of the Cell by Alberts B., Bray D. Lewis J., garland publishing Inc.
20. Genetics Vol. I and II by Pawar C. B., Himalaya publication.
21. Essentials of Molecular Biology by Freifelder D., narosa publication House.
22. Molecular Cell Biology by Laodish H., Berk A., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell J., W. H. Freeman and Co.
23. The Cell: Molecular Approch by Cooper G. M.
24. Molecular Biology by Upadhay A and Upadhay K. Himalaya publication.

Semester-IV

PGZO4T4 Paper-4T4, Electives

1. Mammalian Reproductive Toxicology and Fertility

Course Outcomes (COs)

Students will be able to distinguish and describe the prevalence and risk in male and female reproductive system with respect to chemical and environmental toxicants including radiations, heavy metals, pesticides etc. Analyse the complex but highly organized physiological and molecular processes of preimplantation, foetal programming and prenatal development till the time of labour with respect to endocrine regulator. Comprehend the information of different traditional and advanced contraceptives, sterilization techniques and pregnancy vaccines to prevent unintended pregnancies that help to lower the maternal ill health and the number of pregnancy related death. Discriminate the various contraceptive mechanism in male to create physical and chemical barrier preventing sperm from reaching the oocyte with the help of surgical technique, antagonist, antibodies, anti-androgenic and anti-spermiogenic compounds. Prepare, identify, differentiate and explain the histological slides of female and male reproductive organs intoxicated with some antifertility drug, heavy

metals and pesticide on ovary, uterus, thyroid gland, various stages of development of mammalian egg, development of foetal membranes, types of placenta and progestational changes in uterus.

Semester-IV
PGZO4T4 Paper-4T4, Electives
2. Mammalian Reproductive Toxicology and Fertility

UNIT-I

1.1 Chemical toxicants and Testicular toxicity.
1.2 Impact of environmental and occupational factors on reproductive health.
1.3 Infertility- Radiation, heavy metals and pesticides.
1.4 Genotoxicity on reproduction.

UNIT-II

2.1 Preimplantation development of mammalian embryo and its regulation.
2.2 Placental role in foetal programming
2.3 Major developmental events during the fetal period in mammals (Ex. Human).
2.4 Onset and endocrine control of parturition.

UNIT-III

3.1 Intrauterine and intra cervical devices (IUDS and IUCDS) medicated and nonmedicated IUD's, long acting steroidal contraceptives.
3.2 Surgical sterilization and medical termination of pregnancy (MTP).
3.3 Pregnancy vaccine (anti-HCG, Antizona vaccine, immunization with FSH).
3.4 Recent advances in female contraception (inhibin, prostagladin, hormone analogues, subdermal implants).

UNIT- IV

4.1 Vasectomy and reversible vas occlusion.
4.2 LH-RH antagonist, estrogen antagonist, GnRH antagonist.
4.3 Anti-androgen and anti-spermiogenic compounds (LDH-Cy and Sp-10), Inhibin.
4.4 Antibodies for acrosomal enzymes and sperm surface proteins.

Suggested readings

1. Mammalian Reproductive Toxicology and Fertility

1. A textbook of in vitro fertilization and assisted reproduction edited by P.R. Brinsden and P. A. Rainsbur Jaypee brothers 1992.
2. Advances in Reproductive Physiology, Vol. 1 to 6: Mclaren, (1968). Logos Press Ltd., London.
3. Advances in Reproductive Toxicology eds. S. C. Joshi and A. S. Ansari Pointer publishers.
4. Andrology. 2nd Edition Male Reproductive health and dysfunction (Eds. E. Nieschlag

& H.M. Behre) 2000.
5. Biochemistry of Mammalian Reproduction: Zanveld, L.J.D. & R.T. Chatterton (1982). John Wiley & sons, New York.The Ovary.Vol. I, II & III: Zuckerman, S, (1962). Academic Press, London.
6. Biology of Gestation: Assalye, N.S. (1968). Academic Press, London.
7. Biology of ovarian follicles in mammals (1985). S. S. Guraya Springer-Verlag.
8. Comparative cellular and molecular biology of testis in vertebrates (Trends in endocrine, paracrine and autocrine regulation of structure of functions) (2001) S.S. Guraya, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta.
9. Comparative Endocrinology and Reproduction. Eds. K.P. Joy, A. Krishna and C. Haldar, Narosa Publishing House (1998).
10. Contraceptive Technology Past, Present and Future: Das. R.P. (1989). N.I.H.F.W. New Delhi.
11. Control of ovulation: Crighton, D.B., Haynes, N.B. Foxcroft, G.R. & G.E. Lamming (1978). Butterworths, London.
12. Encylopedia of Reproduction Vol. I, II, III, IV eds. Ernst Knobil and J.D. Neill (1998).
13. Endocrinology and metabolism. 4th edition 2001. Philip Felig & Lowrence A. Frohmon McGraw Hill Inc. Medical Publishing Division.
14. Endocrinology. Vol. 1 to 3: L.J. Degroot et al. (1989). W.B. Saundors Co. Philadelphia.
15. General Endocrinolgoy: Turner, C.D. & J.T. Bagnara (1990) W.B. Saunders Co., & Toppan Co., Philadelphia, London & Tokyo.
16. Hormonal Control of Lactation: Cowie, A.T. Forryth, I.A. and I. Hart (1980). Springer- Verlag, Berlin & New York.
17. Mammalian Oviduct: Hafez, E.S., and R.J. Blandu. The University of Chicago Press, Chicago, London.
18. Marshall's Physiology of Reproduction. 4th Edition Vol. 3 Pregnancy and Lactation Part I, II, III edited by G.E. Lamming, Champan and Hall.
19. Ovarian Cycle of Mammals: Perry, J.S. Oliver and Boyd, Edinburgh.
20. Patterns of Reproduction: Asdell, S.A. (1964). Constable and Co. London.
21. Physiology of Lactation: Smith, Vearch, Constable & Co., London.
22. Postgraduate Reproductive endocrinology. 4th Edition. 1997. R. Rajan Jaypee brothers. Medical Publishers (P) Ltd.
23. Practice of fertility control, Choudhary S. K. Churchill and Livingstone.

Semester-IV

PGZO4T4 Paper-4T4, Electives

2. Respiratory and Reproductive Physiology

Course Outcomes (COs)

The students will be able to describe and explain the physiological anatomy of the respiratory system and illustrate the mechanism of respiration along with breathing and the exchange of respiratory gases at the pulmonary surface. Illustrate the mechanism of transport of respiratory gases (O_2 and CO_2) by blood. Describe and explain lung volumes and capacities, and partial pressure of gases. Illustrate and compare the neural and chemical

regulation of respiration, hypoxia and cyanosis. Describe, explain and compare artificial respiration, oxygen therapy and various infectious respiratory diseases (COVID-19, SARS, Swine Flu). Describe and explain the structure of the male and female reproductive systems, hormonal regulation, menstrual cycle, menstrual abnormalities, andropause and menopause. Describe and explain the mechanism and hormonal regulation of pregnancy, development of mammary glands along with synthesis, secretion, ejection and composition of milk and effects of lactation on the menstrual cycle. Compare and differentiate physiological roles of ovarian and testicular steroid hormones. They could illustrate the causes, symptoms and treatment of infertility in males and females along with In-Vitro Fertilization (IVF). They will be able to demonstrate the percentage of lactose in the milk. Further they will able to demonstrate the effects of various factors on the dissolved oxygen of water.

Semester-IV

PGZO4T4 Paper-4T4, Electives

2. Respiratory and Reproductive Physiology

UNIT-I

1.1 Physiological anatomy of respiratory system.
1.2 Mechanism of respiration – Mechanism of breathing and the exchange of respiratory gases at pulmonary surface.
1.3 Transport of respiratory gases by blood- Transport of O_2 and CO_2, O_2 and CO_2 dissociation curve.
1.4 Lung volumes and capacities, partial pressure of gases.

UNIT-II

2.1 Neural and chemical regulation of respiration
2.2 Hypoxia, Cyanosis.
2.3 Artificial respiration and Oxygen therapy
2.4 Infectious respiratory diseases (COVID-19, SARS, SWINE FLUE)

UNIT-III

3.1 Male reproductive system- Spermatogenesis, Sertoli cell, Leydig cell and hormonal control of spermatogenessis.
3.2 Female reproductive system- Oogenesis, Follicular cells, Corpus luteum and Hormonal control of oogenesis
3.3 Menstrual cycle- Mechanism, hormonal regulation and abnormalities.
3.4 Andropause and Menopause- causes, symptoms and treatments.

UNIT- IV

4.1 Pregnancy- Fertilization, implantation of embryo and parturition, Hormonal regulation of pregnancy.
4.2 Physiology of lactation- Development of the Breasts, mechanism of

lactation, composition of milk. Lactation and menstrual cycle.

4.3 Ovarian and testicular steroid hormones and their physiological role.

4.4 Causes of infertility in male & female and its treatment, In vitro fertilization (IVF).

Suggested readings

2. Respiratory and Reproductive Physiology

1. Essentials of Human Anatomy & Physiology (12th Edition)-Elaine N. Marieb and Suzanne M. Keller (2018, 2015, 2012) Pearson Education, Inc.
2. Human Physiology, (15th Edition) Stuart Ira Fox and Krista Lee Rompolski, McGraw-Hill Education
3. Medical Physiology, (3rd Edition) (2017) by Elsevier
4. Physiology, (6th Edition) Linda S. Costanzo (2018) Elsevier.
5. Ganong's Review of Medical Physiology (26th Edition) Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks and Jason X.-J. Yuan (2019) McGraw-Hill Education.
6. Guyton and Hall Textbook of Medical Physiology 14th Edition John E. Hall and Michael E. Hall (2021) Elsevier.
7. Guyton and Hall Textbook of Medical Physiology (11th Edition) Arthur C. Guyton and Michael E. Hall (2006) Elsevier.
8. Principles of Anatomy & Physiology (15th Edition) Gerard J. Tortora and Bryan Derrickson (2017) John Wiley & Sons.
9. Principles of Anatomy & Physiology (13th Edition) Gerard J. Tortora and Bryan Derrickson (2012) John Wiley & Sons.
10. Human Physiology-From Cells to Systems (7th Edition) Lauralee Sherwood (2010, 2007) Brooks/Cole, Cengage Learning.
11. Human Physiology-From Cells to systems (4th Canadian edition) Sherwood and Ward (2019) Nelson Education Ltd.
12. Essentials of Medical Physiology (6th Edition) K Sembulingam and Prema Sembulingam (2012) Jaypee Brothers Medical Publishers.
13. CC Chatterjee' s Human Physiology (12th Edition) Vol. I Nitin Ashok John (2018) CBS Publishers & Distributors Pvt. Ltd.
14. CC Chatterjee' s Human Physiology (12th Edition) Vol. II Nitin Ashok John (2018) CBS Publishers & Distributors Pvt. Ltd.
15. Samson Wrights Applied Physiology: Oxford University Press.
16. Comparative Animal Physiology C.L. Prosser, W.B. Saunders & Company.
17. Animal Physiology: Mechanism & Application, R. Eckert, W.H. Freeman & Company.
18. General & Comparative Animal Physiology: W.S. Hoar.
19. Medical Physiology: A Wiley Medical Publication, John Wiley & Sons, New York.
20. A Text Book of General Physiology: Dayson (1964): Little Brown & Co. Boston.
21. Animal Physiology: R. Eckert & D. Randall (1983) 2nd Edn., W.H. Rexeman &Co.
22. Biochemistry & Physiology of the Cell: (2nd Edn.), M.A. Edwards & K.A. Hassall (1980) Mc. Graw Hill Co.

Semester-IV

PGZO4T4 Paper-4T4, Electives

3. Fishery Technology and Fish Pathology

Course Outcomes (COs)

Students gain ability to explain, describe and compare different techniques such as craft, gears use in inland water, management and conservation of fish and water pollution. Students could also gain knowledge and will able to culture zooplankton, manufacture and could maintain aquarium. They could explain and describe skillful processes of fish marketing, fishery economics and extension, fish hybridization and transgenic fishes. They could also explain and describe sex determination, sex reversal, fish products and fish by-products and fish pathology. Demonstrate effects of cold and hot stress on total RBCs and WBCs in fish blood as well as separate the different proteins according to their molecular weights by SDS-PAGE electrophoresis.

Semester-IV

PGZO4T4 Paper-4T4, Electives

3. Fishery Technology and Fish Pathology

UNIT-I

1.1 Construction and maintenance of fish farm.
1.2 Gears and crafts in inland water.
1.3 Fishery management and conservation.
1.4 Water pollution and inland fisheries.

UNIT-II

2.1 Plankton in relation to fish production.
2.2 Culture of zooplankton (Daphnia, Artemia, Monia).
2.3 Manufacture and maintenance of Aquarium.
2.4 Hybridization and transgenic fish.

UNIT-III

3.1 Fish marketing: Marketing practices, marketing channels and systems.
3.2 Fishery economics and extension.
3.3 Sex determination, sex reversal and chromosomal manipulation in fish
3.4 Fish conservation: In-situ and Ex-situ, cryopreservation technique and its applications.

UNIT-IV

4.1 Spoilage and methods of preservation of fish: i) Refrigeration and freezing, ii) Freeze drying iii) Canning iv) Drying v) Salting vi) Smoking

4.2 Fish products and byproducts: i) Fish body oil ii) Fish liver oil iii) Fish meal iv) Isinglass v) Hydrolyzed protein (fish flour) vi) Fish glue vii) Fish manure

4.3 Fish pathology: i) Signs of sickness and effects on fish, ii) Pathological procedure for diagnosis of fish diseases

4.4 Fish diseases and its control: a) Viral diseases b) Bacterial diseases c) Fungal diseases d) Protozoan diseases.

Suggested Readings

3. Fishery Technology and Fish Pathology

1. Fish Physiology Vol. 1 to 13: Hoar H.S. & Randall (Eds.) (1964-1994) Academic press London, New York.
2. The physiology of fishes Vol. 1&2: Brown M. E. (1957) Academic press, New York.
3. Natural history of fishes & systematic of fresh water fishes: P Datta Munshi, J.S. & Shrivastva, M. P. (1988): Narendra pub. House, Delhi.
4. Air breathing fishes of India- Their structure, function and life history: Dutta Munshi, J. S., Hunghes G.M. (1992). Oxford and JBH publication Co. New Delhi.
5. The freshwater fishes of India, Pakistan, Bangladesh, Burma and Shri Lanka Handbook: Jayaram, K.C. (1981): Zoological Survey of India, Calcutta.
6. Fish migration: Jones, F.R. S. (1968), E.Arnold, London
7. Aquaculture, Bardach, Ryther and Mc Lamy
8. Marine fisheries: D. K. Dal, K. V. Rao
9. Ichthyology: Lagler, K. F., Bardach, J. and Miller, R.(1977) John Wileys and sons.
10. Fish Endocrinology: Matty, A. J. (1985), Chapman and Hall, London.
11. An aid to the identification of common commercial fishes of India and Pakistan: Mishra K. S. (1982).
12. Aquaculture: The farming and husbandry of freshwater and marine organism: Bardach, J.E. (1974). Narendra Publication House, New Delhi.
13. Handbook of breeding of Indian Major Carps by pituitary hormone injection: Chonder, S. L. (1970). Satish book enterprises, Agra.
14. Diseases of fish: Duijin, C: Van Inr. (1973), life books London.
15. Fish and fisheries of India: Jhingran, V. G. (1985). Hindustan Publication Company, New Delhi.
16. Prawns and prawn fisheries of India: Kurian, C.V. and Sebastian, V. O. (19876). Hindustan Publication Company, New Delhi.
17. The Sea food Industry: Martin, R. E. (1990). Narendra Publication House, New Delhi.
18. Ecological effects of water, applied limnology and pollutant effect: Welch, E. B. (1992).
19. A compemendium of aquaculture technologies: Sinha, V.R. P. (1993). Oxford and JBH publication Co. New Delhi.

Semester-IV

PGZO4T4 Paper-4T4, Electives

4. Medical, Veterinary and Industrial Entomology

Course Outcomes (COs)

Students will able to identify, classify and differentiate the various medical and veterinary pest belonging to different orders and study mode of transmission of diseases by insect vectors such as mosquitos, flies, lice and fleas. They study nature of damage cause by horse and cattle pest and their control measures. Explain and describe economic importance and current national status of Sericulture, Lac culture and Apiculture. Students could demonstrate and dissect out silk gland from infected silkworms as well as could demonstrate infections in silkworms by using histo-pathological techniques.

Semester-IV

PGZO4T4 Paper-4T4, Electives

4. Medical, Veterinary and Industrial Entomology

UNIT –I

1.1 Types of mode of transmission of diseases by insect vectors: Mechanical, Biological and Myiasis.

1.2 Mosquitoes (*Anopheles, Aedes, Culex*) causing disease in man: life cycle of mosquitoes, mode of transmission of pathogens and control measures.

1.3 Flies (Sandfly, Blackfly, Housefly, Tsetsefly) causing disease in man: life cycle of flies, mode of transmission of pathogens and control measures.

1.4 Lice and fleas causing disease in man: life cycle, mode of transmission of pathogens and control measures.

UNIT -II

2.1 Horseflies and Stableflies: Nature of damage, life cycle and control measures.

2.2 The Horse ked and Equine Botflies: Nature of damage, life cycle and control measures.

2.3 The Buffalofly and Cattle warblefly: Nature of damage, life cycle and control measures.

2.4 Cattle Biting louse: Nature of damage, life cycle and control measures.

UNIT -III

3.1 Mulberry silkworm *Bombyx mori*, life cycle, silk gland and silk proteins.

3.2 Silkworm rearing, cocoon harvesting and seed production.

3.3 Bacterial and viral diseases in silkworm.

3.4 Lac insect-biology, lac cultivation and economic importance.

UNIT -IV

4.1 Tasar sericulture- life cycle, host plant, rearing, cocoon formation and silk production.

4.2 Eri sericulture- life cycle, host plant rearing and silk production.

4.3 Honey bee- types, life cycle, colony formation and apiary products.

4.4 Bee keeping- movable frame hive, bee rearing management and diseases.

Suggested readings

4. Entomology

1. Imms General text book of Entomology, Eds. O. W. Richards and R. G. Davis Chapman and Hall, London.
2. General and Applied Entomology, K.K. Nayar, T. N. Ananthkrishan and B.V. Davis Tata McGraw -Hill Co.Ltd. Bombay.
3. The Insect: Structure and function, R.F. Chapman, Cambridge University Press.
4. The Physiology of Insect, Ed. M.Rockstein ,Vol, 1-5, Academic Press, New York.
5. The Physiology of Insect Reproduction, F, Englemann, Pergamon Press, New York.
6. Comprehensive Insect Physiology, Biochemistry and Pharmocology , Eds. G.A. Kerkut and I. A. Gillberd, VOL. 1-13, Pergamon Press, New York.
7. Analytical Biochemistry of Insect, Ed. R. B. Turner, Elsevier, Amsterdam.
8. Insect Hormone, M. J. A. Novak. Chapman and Hall, London.
9. Modern Entomology (Second edition): D. B. Tembhare, Himalaya Publication House, Bombay.
10. Destruction and Useful Insect, Their Hanits and Control, C. L. Metcalf, W. P. Flint and R. I. Metcalf, Mc Grow I Ill Co. New York.
11. Integrated Pest Management, J.L. Apple and R. E. Smith, Plenum Publication Co., New Delhi.
12. An Introduction Of Biological Control RVD Boarscho, P. S. Y. Messenger and A. P. Gaiter, Plenum Publication Co.
13. Text Book of Entomology, K. P. Shivastava, Vol. 1 And 2 Kalyani Publication, Ludhiana.
14. Agriculture Entomology, H. S. Dennis, Timber Press Inc.
15. Entomology and Pest Management, Larry P. Pedigo, Prentice Hall.
16. Text Book of Agriculture Entomology, Alford V. David, Blackwell Science.
17. Biopesticides In Insect Pest Management, S. J. Ignacimulha and Alok Sen, Phoenix Publishing House Pvt, Ltd.
18. Biotechnology in Invertebrate Pathology and Cell culture (Maramorosch, K. ed.). Academic Press, New York.
19. PEBFANS (2003)" (Solomon Raju, A. J. ed.). Andhara University Press, Visakhapatnam.
20. Living Resources for the Millennium 2000 (S. J. William ed.), Students Offset Press, Chennai.

PGZO4P2, Research Project (RP) Major Work

Course Outcomes (COs)

After completion of major research project student will able to select proper problem (Title). Plan and develop experimental design for projects. Select and learn to use the proper methods and materials for his/her research work. Analyse and interpret the results. Draft the scientific write up and submit in the form of thesis. Learn and write bibliography by various styles.

PGZO4P2, Research Project (RP) Major Work

In this major research project, topic will be based on elective opted by the students. Project will include laboratory-based work. Project report to be submitted and presented including viva-voce. The evaluation of this major project will be done at departmental level by the approved internal and external examiners.