

## **I – M. Sc. ZOOLOGY**

### **SEMESTER – I**

#### **PAPER – I: BIOSYSTEMATICS, ANIMAL BIODIVERSITY AND PHYLOGENY**

##### **OBJECTIVES**

- *To obtain a thorough understanding of the principles and practices of systematics.*
- *To acquire an indepth knowledge of the diversity and relationships in the animal world.*
- *To develop a holistic appreciation of the geological time scale, fossils, phylogeny and adaptations in animals.*

##### **UNIT - I: BIOSYSTEMATICS – BASIC CONCEPTS**

Definition and basic concepts - Three domain concept.

Two, Five and Six Kingdom Classifications.

Species concept – Taxonomic diversity within species.

##### **UNIT-II: BIOSYSTEMATICS – METHODS**

Keys used for classification (ICZN) (Phylum level) - Homonymy and Synonymy.

Ethics in Taxonomy – Authorship, Suppression of data, Undesirable practices in taxonomy.

Molecular Phylogeny – Use of Proteins, DNA, RNA.

##### **UNIT-III: INVERTEBRATE ANIMAL DIVERSITY**

Animal classification upto class level with examples.

Connecting link between Annelida and Arthropoda (Peripatus), Annelida and Mollusca (Neopilina).

Adaptive radiation in Annelida.

##### **UNIT-IV: CHORDATE ANIMAL DIVERSITY**

Systematic position of Prochordata.

Animal classification of Chordata up to order level.

Adaptive radiation in Class Mammalia.

Connecting link between Amphibia and Reptilia (Seymouria); Reptilia and Mammalia (Ornithorhynchus).

## **UNIT-V: ANIMAL PHYLOGENY**

The Geological Time Scale, Fossils- Formation, Kinds and Uses of Fossils.

Living fossils - Limulus, Coelacanth, Sphenodon.

Problems and adaptations in terrestrialization- Origin of paired limbs.

Specialized modern mammals –Monotremes, Marsupials, Aquatic Mammals.

Phylogenetic tree- Schematic representation.

## **REFERENCES**

- **Joseph Karunakaran, Devasakayam and Inbamani.** Animal Phylogeny.
- **Barnes. R.D.,**1974 Invertebrate Zoology. W.B.Saunders Co., Philadelphia.
- **De Beer. G.R.** The Evolution of Metazoa(1954).
- E-Mayer-Elements of Taxonomy.
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- **Jolie, M.,** 1968. Chordate Morphology. East West Press. Pvt. Ltd,
- **Kapoor, V.C.**1991. Theory and Practice of Animal Taxonomy. Oxford and IBH Publishing Co., Pvt. Ltd. New Delhi.
- **M. Koto-**The Biology of Biodiversity- Springer
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- **Young, J.Z.**1969. Life of Vertebrates. Clarendon Press, Oxford.

## I - M. Sc. ZOOLOGY

### SEMESTER - I

#### PAPER – II: ENVIRONMENTAL BIOLOGY

##### OBJECTIVES

- *To provide an understanding of the concepts and disciplines of ecology.*
- *To study the structure, functions and types of ecosystem.*
- *To gain a critical understanding of the impact of man on the environment.*
- *To develop an appreciation of the resources of India and the conservation initiatives undertaken.*

##### UNIT - I

1. Definition, Scope and Divisions of Ecology.
2. Biotic environment, Abiotic components; Atmosphere- Stratification; Gases, Wind, Temperature.
3. Concept of habitat and niche.
4. Species interactions -Types of interaction- Commensalism, Mutualism, Symbiosis, Competition.
5. Biogeography – Biogeographical zones in India.

##### UNIT - II

- 1, Ecosystem - Structure and Function, Primary production, Energy flow in ecosystem.
2. Terrestrial ecosystem - Desert, Grassland.
3. Aquatic ecosystem - Fresh Water - Lentic, Lotic.
4. Marine – Stratification, Intertidal shores, Deep Sea.
5. Estuarine ecosystem.

##### UNIT - III

1. Population ecology – Characteristics, Population growth curve, Regulation, Demes and Dispersal.
2. Ecological succession - Types, Mechanism, Significance, Climax concept.
3. Community ecology – Nature of community, Structure, Stratification, Edge and Ecotone.
4. Natural resources – Water, Forest.
5. Conventional and Non-conventional energy resources.

##### UNIT - IV

1. Environmental pollution - Air, Water, Land, Radioactive pollution, e-pollution.
2. Global warming and Climate change.
3. Sustainable Development, Earth Summit.
4. Disaster management.

## **UNIT - V**

1. Biodiversity in India.
2. Wildlife sanctuaries, National parks, Biosphere Reserves in India.
3. Endangered species and their conservation.
4. Environmental monitoring and Impact Assessment.
5. Western Ghats and its significance, Project Tiger.

## **REFERENCES**

- **Agarwal. K. C.** Biodiversity. Agro Botanical Publishers
- **Ananthkrishnan, T.N.,** Bioresources Ecology, Oxford.
- **Desanto R.S.** Concept of Applied ecology. Springer Varlag.
- **Mani,M.S.** Ecology and Bio-geography in India.1974.
- **Odum, E. P.,** Fundamentals of ecology. W.B. Saunders & co.
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- **Philipson. J.** Ecological energetics. St Martis
- **Sharma. P.D.** Ecology and Environment. Rastogi Pub., Meerut.

## I – M.Sc. ZOOLOGY

### SEMESTER – I

#### PAPER– III: CELL AND MOLECULAR BIOLOGY

##### OBJECTIVES

- *To obtain an insight into the architecture and function of the cell organelles at the molecular level.*
- *To understand the structure and mechanisms that facilitate the constant engagement of the cell with its environment.*
- *To understand how the construction and regulation of genetic materials ensures the accurate copy, repair and interpretation of genomic information.*

##### UNIT - I: Cell Organization

**Plasma Membrane** – Structure – Bilayer Model (Fluid Mosaic Model), Micellar Model.

- Chemical Composition–Membrane Lipids, Carbohydrates, Proteins
- Asymmetry of Membrane Lipids, Carbohydrates, Proteins.
- Movement of Solutes – Diffusion of Water, Diffusion of ions through Ion- selective channels, Passive transport, Active transport, Transport ATPases.

**Cytoskeleton** – Microtubules, Microfilaments, Intermediate Filaments – Structure and Function.

**Endoplasmic Reticulum** – Ultrastructure – SER, RER, Functions, Protein import.

**Ribosomes** – Structure and Function.

##### UNIT - II: Cell Organization

**Golgi complex** – Ultrastructure, Polarisation (*cis* – *trans*), Compartmentalization, Chemical Composition, Functions.

**Mitochondria** – Structure– Mitochondrial membranes and Mitochondrial DNA.

- Functions – Electron Transport System – Organization, Mechanism, Inhibitors. Electron Carriers. Oxidative Phosphorylation – Mechanism, Inhibitors, Translocation of ADP and ATP.

**Peroxisome** – Morphology and Function.

**Lysosome** – Morphology, Constituent Enzymes, Function.

##### UNIT - III: Cell and its Environment

**Cell – Cell Signaling** – Signal transduction pathway (by GPCRs).  
**Cell – Cell Adhesion** – Ca<sup>++</sup> - dependent and Ca<sup>++</sup> independent homophilic adhesions,  
 Selectins.  
**Cell – Junctions** – Occluding, Anchoring and Communicating Junctions.  
**Cell Matrix Adhesion** – Focal adhesions, Hemidesmosomes and Integrins.  
**Apoptosis** – Apoptosis in *C. elegans* and Vertebrates, Significance.  
**Aging** – Concept and Causes.  
**Cancer Biology** – Genetics of Cancer - Oncogenes and Tumor suppressor genes.

#### **UNIT – IV: Genetic Organization and Mechanisms**

**DNA – Structure** (Watson – Crick model), Conformations (Z, A and B forms).  
**DNA – Topology** – Supercoiling, Topoisomerases I&II.  
**RNA – Structure** of mRNA, tRNA and rRNA.  
**DNA – Replication** -Semi conservative mode.  
**DNA – Repair** (Nucleotide excision repair, Base excision repair, Mismatch repair).

#### **UNIT – V: Genetic Mechanisms**

**Transcription in Prokaryotes** – Initiation - Recognition, Binding, Elongation and Termination.  
**Transcription in Eukaryotes** – Promoters, Initiation with Polymerase I, II, III, Elongation, and Termination  
**Post – Transcriptional modifications in mRNA** – Mechanism - Capping, Splicing.  
**Translation**  
**Protein Folding** – Chaperone-mediated, Abnormal folding - CJD disease.  
**Regulation of Gene Expression** – In Prokaryotes, In Eukaryotes.

#### **REFERENCES**

- **Ajoy Paul**, Textbook of Cell and Molecular Biology; 3<sup>rd</sup> Edition (2011); Books & Allied (P) Ltd. Kolkata.
- **Gerald Karp**, Cell and Molecular Biology; 5<sup>th</sup> Edition (2008); John Wiley & Sons (Asia) Pvt. Ltd.

# **I – M.Sc. ZOOLOGY**

## **SEMESTER – I**

### **ELECTIVE PAPER – I: FISHERY BIOLOGY**

#### **OBJECTIVES**

- *To appreciate the scope of the study of Fishery Biology.*
- *To understand the structure and functioning of different organ systems.*
- *To acquire an indepth understanding of the unique features of fish biology.*

#### **UNIT - I**

Introduction and Scope of Fishery biology.

Classification up to order level with South Indian examples.

Latimeria – Dipnoi – Salient features – Distribution – affinities.

#### **UNIT - II**

Types of scales and fins – uses of scales in growth studies.

Coloration and colour change – Bioluminescence.

Electrogenesis – Electric organs.

Poison gland and venomous fishes.

Sense organs – Lateral lines, Ampullae of Lorenzini, Pit organs, Organs of Savi, Eyes and Ears.

Deep – sea adaptations.

#### **UNIT - III**

Live food, Synthetic fish feeds.

Nutritional requirements of fishes.

Feeding habits – Structure and modification of alimentary canal in relation to mode of feeding.

Stress and growth inhibition by hormones in fish.

South Indian food fishes – marine and fresh water.

#### **UNIT - IV**

Circulatory system – Heart, arterial and venous system in Shark.

Gills, Accessory respiratory organs.

Excretion – Osmoregulation – Locomotion and migration.

Parental care.

#### **UNIT - V**

Endocrine organs in fishes.

Hypophysation and Induced breeding.

Hybridization – Transgenic fish – Triploids (Broiler fish).

Inbreeding, crossbreeding and selective breeding.

Cryopreservation of gametes – monosex culture – sex reversal – sterile fish.

## REFERENCES

- **Datta Munshi, J. S. and Shrivastava, M.P.** 1988. National History of Fishes and Systematic of Fresh water fish of India.
- **Day, F.** 1878. Fishes of India, Vol. I and II – Williams Dawson and sons.
- **Jhingran, V.G.** 1987 Fish and Fisheries of Indian, Hindustan Publishing Corporation Delhi – 7.
- **Karl F Lagler, John E Bardach, Robert R Miller and Dorr Ra Mary Passiono,** 1970 'Ichthyology', John Willy and son New York.
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- **McDaniel** (ed.) 1978. Procedure for the detection and identification of certain Fish Pathogens, Washington Fish Health Section, American Fishery Society.
- **Ribelin W.E.** (ed.) 1975. Pathology of Fishes. Madison – Wiscosin University, Wisconsin Press, U.S.A.
- **Robart, R. J.** (ed.) 1978. Fish Pathology, BallaireTindele London.
- **Shunmugam K.** 1922. Fishery Biology and Aquaculture Leo Pathippagam, Madras 83
- **Yadav** – Fish and Fisheries, Daya Publishing House, Delhi – 110 035.
- **Jayaraman, K.C.** The fresh water Fish of Indian Region. Narendra Publication House. 1417, KishabDuti Street, Madivara, Delhi – 110 006



## **I - M.Sc. ZOOLOGY**

### **SEMESTER – II**

#### **PAPER – IV: BIOSTATISTICS, BIOTECHNIQUES AND BIOPHYSICS**

##### **OBJECTIVES**

- *To develop sorting, analytical, critical thinking and problem solving skills in data handling.*
- *To introduce the tools and techniques available for the study of the biochemical and biophysical attributes of life.*

##### **BIOSTATISTICS**

###### **UNIT - I**

Collection of data – Primary and Secondary.

Diagrammatic and Graphic representation of data.

Tabulation of data, Frequency distribution.

Measures of Central tendencies.

Measure of dispersion – Co-efficient of variation – Standard error of sample and populations.

###### **UNIT - II**

Probability (Binomial only).

Correlation and regression.

Test of Significance – Student's 't' test of samples-confidence limits.

Analysis of Variance (ANOVA). Chi-square test.

DMRT.

##### **BIOTECHNIQUES**

###### **UNIT - III**

Micro-technique – Fixation, Decalcification, Dehydration, Impregnation, Embedding, Sectioning and Staining.

Principles and application of chromatography – Paper, HPLC, Gas and Liquid chromatography

Principles and application of electrophoresis – Paper and Gel (PAGE and SDS – PAGE).

###### **UNIT - IV**

Microscopy – Phase contrast microscope - Interference microscope – Transmission and Scanning electron microscopes.

Characteristics of Electromagnetic radiation – Biological applications of X-rays, UV rays and lasers.

Surface plasmon resonance.

Principles of Photography, Microphotography.

## **BIOPHYSICS**

### **UNIT - V**

Colorimetry, Spectrophotometry, Flamephotometry and GC-MS in biology – Principles, Applications and Types.

pH meters and their application in biology, Construction of glass and calomel electrode.

NMR and ESR.

Flow cytometry. X – Ray Diffraction.

### **REFERENCES**

- **Gupta, S.P.** 1976. Statistical method. Sultan Chand and Sons, New Delhi.
- **Gupta, C.B.** 1976. An Introduction to statistics methods. Vikas Publishing. New Delhi.
- **Bailey, N.J.** 1965. Statistic for Biological Sciences. Addition Wesley.
- **Campbell, R.D.** 1967. Statistics of Biologists. Cambridge Uni. Press.
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- **Varley**, Practical Clinical Biochemistry, Ed. Alan H. Gowen Lock., Neinemann Medical Books.
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- **Jayaraman, J.** 1987. Techniques in Biochemistry IBH, Oxford.
- **S. Palanichamy, and M. Shunmugavelu.** Principles of Biophysics, 2002..
- **Subramanian.** Biophysics – Principles and techniques,.
- **Dr.R.N.Roy.** A Text book of biophysics-.

# I - M.Sc. ZOOLOGY

## SEMESTER - II

### PAPER – V: ANIMAL PHYSIOLOGY AND BIOCHEMISTRY

#### OBJECTIVES

- *To understand the functioning of different organ systems with reference to man/mammals.*
- *To compare the physiological processes of certain systems across the animal kingdom.*
- *To appreciate the chemical foundations of life processes.*
- *To understand the structure and metabolism of biologically significant molecules.*

#### ANIMAL PHYSIOLOGY

##### UNIT – I

1. Blood – Physiology of blood clotting.
2. Circulation – Pacemaker – conducting system – Electrical excitation of heart – ECG.
3. Temperature regulation in homeotherms.
4. Respiration – Respiratory pigments – Gaseous transport.

##### UNIT II

5. Excretion – Types of excretory products – Patterns of excretion – Nephron structure  
Physiology of urine formation.
6. Osmotic and ionic regulation.
7. Biological rhythms – (Circadian rhythm, Biological Clock).
8. Bioluminescence and Bioelectricity – Brief account.

##### UNIT III

9. Nerve impulse propagation – Synaptic transmission – Neurotransmitters.
10. Ultra structure of muscle - Chemical basis of muscle contraction.
11. Physiology of Vision.
12. Physiology of hearing.

#### BIOCHEMISTRY

##### UNIT IV

13. Structure and biological significance of bio molecules (Glucose, Fatty acids & Amino acids)
14. Glycogen metabolism – Glycogenesis, Glycogenolysis.  
–Glycogen storage Disease – von Gierke's disease.
15. Glucose Metabolism – Glycolysis, TCA cycle, Gluconeogenesis - Diabetes mellitus.

16. Lipid metabolism –  $\beta$ - Oxidation of fatty Acids  
– Lipid metabolic disorders – Refsum's disease, Hypercholesterolemia.

#### **UNIT V**

17. Protein metabolism – Transamination, Deamination, Ornithine cycle. –  
Protein metabolic disorders - Phenylketonuria, Alkaptonuria.
18. Enzymes – Nomenclature, Properties and classification of enzymes.
19. Mechanism of enzyme action, Factors affecting enzyme action.
20. Free Radicals and anti – oxidants.

#### **REFERENCES**

- **U. Satyanarayana & U. Chakrapani**, Essentials of Biochemistry, 2<sup>nd</sup> edition.
- **Hoar, W.S.** 1983. General and comparative physiology. Prentice Hall of India. New Delhi.
- **Harper, H.A. Rodwell, V.N. and Mayes, P.A.**, 1979. Review of physiological chemistry 17<sup>th</sup>edn. Large Medical Publication, Los Atlos, California.
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- **Parameswarn, R., Ananthasubramanian, K.S.** 1989. Outline of Animal Physiology. S. Viswanathan Pvt.
- **West S.E., Tedd, R.W.Masom, S.M. and Bruggen, V.T.T.** Text book of Biotechnology Collier, Mecmillan, 1996.
- **Lehninger, A.L.** Biochemistry. Worth Publishers 1981.
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## I - M.Sc. ZOOLOGY

### SEMESTER –II

#### PAPER - VI: BIOTECHNOLOGY AND GENETIC ENGINEERING

##### OBJECTIVES

- *To provide a solid foundation on the tools and techniques employed in genetic engineering.*
- *To appreciate the contribution of biotechnology in disease diagnosis and advanced therapeutics.*
- *To understand the interface of modern biology and advanced industrial bioprocess technology.*
- *To study the role of biotechnology in environmental protection.*

##### UNIT – I: Tools and Techniques of Genetic engineering

1. **Enzymes** – Restriction endonuclease, DNA Ligase, Alkaline phosphatase, Terminal transferase, Polymerase – Klenow enzyme.
2. **Vectors** – Plasmids, Bacteriophages, Cosmids, Artificial Chromosome Vectors, Shuttle vectors.
3. **Host Cells** – Prokaryotic cells and Eukaryotic cells (Advantages and Limitations).
4. **Nucleic acid Purification** – Cellular DNA, Plasmid DNA, mRNA.
5. **Methods of Gene Transfer** – Transformation, Transduction, Electroporation, Liposome mediated gene transfer, Microinjection, Particle bombardment.

##### UNIT - II: Techniques in Genetic Engineering

6. **Gene Synthesis** – Chemical Synthesis (Phosphoramidite method).
7. **Gene Amplification** – PCR Technique, Types and Applications.
8. **DNA Sequencing** – Sangar Coulson method, Chromosome walking.
9. **Gene Libraries** – cDNA Library.
10. **Site-directed Mutagenesis.**

##### UNIT - III: Medical Biotechnology and Animal Biotechnology

11. **DNA in Disease Diagnosis** –DNA Probes, DNA chip –Microarray.
12. **Gene Therapy** –*ex vivo, in vivo*, Antigene therapy, Antisense therapy.
13. **DNA Fingerprinting and DNA Markers** (RFLP, VNTR, STR, SNP).
14. **Tissue Engineering and Embryonic Stem cell Engineering.**

15. *Pharmaceutical products* – Monoclonal antibodies, Recombinant vaccines.

16. *Transgenic Animals* – **Transgenic mouse.**

#### **UNIT - IV: Industrial Biotechnology**

17. *Microbial Production of Enzymes* – Basic Protocol and Applications.

18. *Immobilization of Enzymes* – Methods and Applications.

19. *Biosensors* – Types and Applications.

20. *Microbial Production of* – Organic Solvent (Ethanol), Organic Acid (Citric Acid), Antibiotic (Pencillin), Amino acid (L – Lysine), Vitamin (Vitamin B12), Fermented food and Beverage (Cheese, Wine).

#### **UNIT V – Environmental Biotechnology**

21. *Bioremediation* – Types, Recalcitrant Xenobiotics, Genetically engineered microorganisms – Applications.

22. *Bioremediation* of Contaminated soil.

23. *Biodegradation* of Hydrocarbons, Pesticides, Polychlorinated biphenyls (PCBs).

24. *Waste Water Treatment* and *Solid Waste Management*.

25. *Biotechnology* – Risks, Ethics and Patenting.

#### **REFERENCES**

- **Sathyanarayana, U.**, Biotechnology, 1<sup>st</sup> Edition (2008), Books & Allied (P) Ltd., Kolkata, India.
- **Dubey, R.C.**, A Text book of Biotechnology. (2003) S.Chand and Co Ltd, Ramnagar, New Delhi.

# I – M. Sc. ZOOLOGY

## SEMESTER – II

### ELECTIVE PAPER – II: APPLIED FISHERY BIOLOGY

#### OBJECTIVES

- *To appreciate the economics of Fishery Biology.*
- *To gain a thorough understanding of Culture Fisheries.*
- *To understand the equipments required for the fishing industry.*
- *To study certain aspects of fish pathology.*
- *To obtain a thorough understanding of the production processes of fish by products.*

#### UNIT - I

Importance of Fisheries and Aquaculture.

Indian fisheries – Fishing seasons – East Coast and West Coast.

Marine fisheries – Off shore and Deep Sea Fisheries.

Non-fish organism fisheries – Prawn fisheries (Marine and fresh water), Oyster fisheries edible and pearl oyster, Mussel and crab fishery.

Over fishing, Global decline in fish catch, Remote Sensing.

#### UNIT - II

Inland fisheries – Riverine – Estuarine – Reservoir – Pond and Cold water.

Fish pond preparation – Integrated fish farming – Predatory fishes.

Fish culture – Monoculture – Composite fish culture – Cage and pen culture – Paddy cum fish culture.

Sewage fed fisheries – culture of air breathing fishes.

Larvicidal fishes.

#### UNIT –III

Fish Gears – Brief account on Seines – Rampani Net – Mathi Kolli Valai, Patten Kolli Valai, Thongu Valai

Trawls – (a) Gill nets – Simple gill net – Mathichala valai – Trammel net

(b) Dip net – Cast net – Fike net – Chinese Dip net.

(c) Rod and Fine traps

(d) Hook and Line – Long line

Fishing Crafts – Dugout Canoes, Dam and Thoni, Vallam and Padagu, Catamarans, Ratnagiri boats and Mechanized boats.

## UNIT - IV

Fish pathology – Diseases and treatment. Pathological changes in tissues – Signs of sickness and Diagnosis of fish disease – Control of fish diseases in fish ponds.

Common infectious diseases- brief account only.

Bacterial (Infectious Dropsy, Furunculosis, GillRot, Erythroderma, Enteritis)

Viral (Epizootic Ulcerative Syndrome, Infectious Pancreatic Necrosis, Viral HaemorrhagicSepticaemia, Erythrocytic Necrosis, Spring Viraemia)

Protozoan (Costiasis, Knot disease, White spot disease, Whirling disease, Cryptobiosis)

Fungal (Gill rot, Saprolegniasis),

Worm and Ectoparasites (Dactylogryosis, Ligulosis, Piscicollis, Argulosis, Caligus).

## UNIT - V

Fish by-products – Fish liver oil – fish meal – fish glue – fish silage – fish manure – fish guano– fish flour– Isinglass– fish leather– fish macaroni– fish biscuits– trash fish and its use.

Fish curing and processing – Rigor mortis – spoilage,

Principles and process of preservation. Methods of fish preservation – Chilling – Freezing – Canning – Drying - Salting – Smoking.

Transportation and marketing – Co-operative movements – Fish culture industry – Bank loans. A brief account on ICAR, CMFRI, CIFT, FSI and NIOT.

## REFERENCES

- **Datta Munshi, J.S. and Shrivastava, M.P.** 1988. Natural history of fishes and systematic of Fresh water fishes in India.
- **Day, F.**, - 1878 – Fishes of Indian, Vol I and II – Williams Dawson and sons.
- **Jhingram, V.G.** 1987, Fish and Fisheries of Indian, Hindustan Publishing Corporation Delhi-7.
- **Shunmugam, K.** 1922 – Fishery Biology and Aquaculture, Leo Pathippagam, Madras 83.
- **Yadav.** Fish and Fisheries, Daya Publishing House, Delhi 45.
- **McDaniel (Ed)** 1978. Procedure for the detection and identification of certain fish pathogens. Washington DC Fish Health Section, American Fishery Society.



## **I - M.Sc. ZOOLOGY**

### **SEMESTER – I & II**

#### **PRACTICAL – I**

**(Papers covering: Paper – I: Biosystematics, Animal Diversity and Animal Phylogeny, Paper – II: Environmental Biology, Paper – III: Cell & Molecular Biology, Elective paper – I & II: Fishery Biology).**

#### **ANIMAL PHYLOGENY**

Spotters limited to animal diversity and fossils.

#### **ENVIRONMENTAL BIOLOGY**

- a. Determination of
  - i) Phosphate,
  - ii) Silicate,
  - iii) Nitrate,
  - iv) Nitrite ,
  - v) Calcium ,
  - vi) Iron in water samples
- b. Plankton collection and identification – quantitative and qualitative estimation of planktons.
- c. Study of Soil Fauna.
- d. Study of adaptive features in Amphibia, Reptiles, Aves and Mammalia.
- e. Animal association – i) Parasitism,ii) Mutualism.

#### **CELL & MOLECULAR BIOLOGY - SPOTTERS**

- a. Dounce homogenizer
- b. Chromatography – HPLC
- c. Autoradiography
- d. Electrophoresis – SDS PAGE
- e. ELISA
- f. X-Ray Crystallography
- g. NMR
- h. Surface Plasmon Resonance (SPR)

#### **FISHERY BIOLOGY**

Identification of marine, brackish and inland fishes.

Morphometric and meristic characters of fish.

Analysis of gut contents.

Length - weight relationship in freshwater fish and marine fish- calculation 'K' (Condition Factor).

Study of fish blood (RBC, WBC, Hb).

Study of scales by temporary mounting.

Dissection of digestive system in relation to feeding habit.

Induced breeding techniques- Demonstration only.

## **I - M.Sc. ZOOLOGY**

### **SEMESTER – I & II**

#### **PRACTICAL – II**

**(Papers covering: Paper – IV: Biostatistics, Biotechniques and Biophysics, Paper – V: Animal Physiology & Biochemistry, Paper – VI: Biotechnology and Genetic Engineering)**

#### **Animal Physiology:**

- Osmoregulation by weight change of crab.
- Counting of blood cells – RBC, WBC, TC and DLC.
- Determination of Bleeding time and clotting time.
- Influence of temperature on oxygen consumption of fish.
- Identification of nitrogenous excretory products.
- Determination of ammonia excreted by fish.
- Determination of Na<sup>+</sup> and Cl<sup>-</sup> ions loss and gain in a freshwater fish.

#### **Spotters:**

- Incubator
- Centrifuge – ultra centrifuge
- pH meter
- Microtome
- Colorimeter
- PCR
- Gel Doc
- Spectrophotometer

#### **Biochemistry:**

- Preparation of haemin crystals.
- Quantitative estimation of the following in blood samples.
  - Glucose
  - Urea
  - Cholesterol
  - Haemoglobin
  - SGOT
  - SGPT
- Quantitative estimation of glucose in urine.
- Quantitative estimation of tissue protein.
- Quantitative estimation of tissue carbohydrate.
- Quantitative estimation of tissue lipids.

**Biostatistics:**

- Collection of data and construction of frequency distribution.
- Diagrammatic representation.
- Arithmetic mean.
- Mean deviation.
- Standard deviation and variance.
- Co-efficient of variation.
- Student's 't' test.
- Chi-square test.

**Biotechniques: Demonstration only**

- Electrophoretic separation of serum proteins.
- Chromatography – 2 dimensional chromatography.
- Paper Chromatography.

**Biophysics:**

- Microphotography.

**Biotechnology:**

- Isolation of DNA from rat liver by Phenol extraction method.
- Study of Antigen-antibody reaction- blood cells precipitation.

## II - M. Sc. ZOOLOGY

### SEMESTER - III

#### PAPER – VII: DEVELOPMENTAL BIOLOGY

##### OBJECTIVES

- *To understand the basic concepts of Development Biology with reference to man.*
- *To study the experimental aspects of Developmental Biology.*
- *To acquire an in depth knowledge of the relationship between genes and development and environment and development.*
- *To appreciate the contribution of the subject to human welfare.*

##### UNIT-I: Basics of developmental biology

- Egg cortex and development.
- Polarity, Form and differentiation.
- Nucleo – cytoplasmic interactions.
- Embryology of human development – Zygote, Cleavage, Differentiation of layers and Placenta.

##### UNIT-II: Experimental Embryology

- Model Organisms.
- Developmental mutants.
- Transgenic organisms in development.
- Cellular and microsurgical techniques.

##### UNIT-III: Genes and Development

- Pleiotropism, Phenocopy, Imaginal discs, Transdetermination.
- Embryonic induction and morphogenesis.
- Genetic control of developmental pathways.
- Regeneration and programming of gene function – Amphibian regeneration.

##### UNIT-IV: Environmental Control of Development

- Photoperiodism and reproduction in animals.
- Environmental control of dormancy and diapause.
- Dependent and Self Differentiation.
- Environmental factors in development

##### UNIT-V: Embryology and Human Welfare

- Teratology – Basic Concepts and their causes.
- Congenital abnormalities and Studies on Twins.
- Assisted Reproductive Techniques.
- Cryopreservation of gametes and embryonic stem cells.

## REFERENCES:

- **Huettner, F. Alfred**, Fundamentals of Comparative Embryology of the Vertebrates. The Macmillan Company, New York.
- **Twyman, R. M.**, Developmental Biology Instant Notes, Viva Books Private Limited, Chennai.
- **Shumway, Waldo and Adamstone, F. B.**, Introduction to Vertebrate Embryology, 5<sup>th</sup> Edition, John Wiley and Sons, New York.
- **Berrill, N. J.**, Developmental Biology, Tata McGraw Hill Publishing Company, New Delhi.
- **Markert, Clement L. and Ursprung, Heinrich**, Developmental Genetics, Prentice-Hall of India Pvt. Ltd., New Delhi.
- **Graham, C. F. and Wareing, P. F.**, The Developmental Biology of Plants and Animals, Blackwell Scientific Publications, Oxford.
- **Verma, P. S. and Agarwal, V. K.**, Chordate Embryology, S. Chand & Company Pvt. Ltd., New Delhi.

## **II - M.Sc. ZOOLOGY**

### **SEMESTER –III**

#### **PAPER – VIII: IMMUNOLOGY**

##### **OBJECTIVES**

- *To understand the immune system with respect to origin, development and structure.*
- *To study in entirety, the cells and effector molecules of the immune system namely, antigens and antibodies.*
- *To understand the underlying complexities and mechanisms of different immune reactions.*
- *To appreciate the clinical manifestations of immunological disorders.*
- *To study the techniques that are integral to immunological studies.*

##### **UNIT – I: INTRODUCTION TO THE IMMUNE SYSTEM**

1. Components of Immunity – Innate Immunity – Acquired immunity.
2. Origin, Development and Structure of the organs of Immune system – Primary Lymphoid organs–(a). Thymus, (b). Bursa of Fabricii, (c). Bone marrow.
3. Secondary Lymphoid organs – (a). Lymph node, (b). Spleen, (c). Lamina propria, (d). Peyer's patches, (e). Tonsils.
4. Cells of the immune system – Lymphocytes, Mononuclear Phagocytes, Granulocytes, Dendritic Cells and Platelets.

##### **UNIT – II: ANTIGENS, ANTIBODIES AND ANTIGEN – ANTIBODY REACTIONS**

5. Antigen – General Properties, Epitopes and Paratopes, Antigenic determinants, Factors for antigenicity.
6. Antibodies – Structure, Classes, Properties and Functions
7. Antigen-Antibody reactions – Salient features, Types – Precipitation, Agglutination, Cytolysis, Flocculation and Opsonisation

##### **UNIT – III: HYPERSENSITIVITY, IMMUNOPROPHYLAXIS AND COMPLEMENT**

8. Complement – Activation – Classical and alternative – functions – Complement fixation.
9. Immunoprophylaxis – Immunization - Active and Passive, Immunization time schedule, Vaccines and hazards.
10. Hypersensitivity – Type 1 - Allergy, Type 2 - Cytotoxic, Type 3 - Immune complex disease, Type 4 - Delayed – type hypersensitivity.

#### **UNIT – IV: TUMOUR, TRANSPLANTATION IMMUNOLOGY, IMMUNODEFICIENCY AND AUTOIMMUNE DISEASES**

11. Tumour Immunology - Causes – Tumour antigens – Immunity against Tumors– Immuno diagnosis, Immunotherapy.
12. Transplantation Immunology – Graft Types –Rejection - Blood Transfusion, Bone Marrow Transplantation – prevention of rejection.
13. Immunodeficiencies – Primary – SCID, CGD  
- Secondary – HIV.
14. Autoimmune Diseases – Chronic Thyroiditis, Myasthenia Gravis, Multiple Sclerosis.

#### **UNIT – V: IMMUNOLOGICAL TECHNIQUES**

15. WIDAL, VDRL, Immunoelectrophoresis.
16. Immunodiffusion, Coomb's Test and Immunofluorescence.
17. ELISA, RIA, HLA Typing and Western blotting.

#### **REFERENCES**

- **Khan, Fathim Halim.** The Elements of Immunology, Pearson Education, Chennai.
- **Roitt, Ivan.** Essentials of Immunology,
- **Dasgupta, A.** Modern Immunology, 2<sup>nd</sup> edition, Jaypee Brothers, Medical Pub., New Delhi.
- **William E. Paul** (ed.) Fundamental Immunology. 2<sup>nd</sup> edition. Raven Press, New York.
- **Egorov, N. S.** Antibiotics – A Scientific Approach. Mir Publishers, Moscow.



## II – M.Sc. ZOOLOGY

### SEMESTER – III

#### PAPER – IX: ENDOCRINOLOGY – I

##### OBJECTIVES

- *To understand the significance of the integration of the neural and endocrine systems in Invertebrates.*
- *To obtain a comparative understanding of the origin and organization of the various endocrine glands across the Vertebrate Kingdom.*

##### UNIT – I

- Concept of neuro-secretions.
- Endocrine control of growth and reproduction in Oligochaetes.
- Endocrine control of growth and reproduction in Polychaetes.
- Endocrine mechanisms in Gastropods.
- Endocrine mechanisms in Cephalopods.

##### UNIT – II

- Endocrine glands in Crustaceans.
- Endocrine control of moulting and metamorphosis in Crustaceans.
- Types of Insect hormones.
- Neuroendocrine system in insects – moulting, metamorphosis and diapause.

##### UNIT- III

- Anatomy of Hypothalamus
- Origin and Structure of pituitary gland
- Comparative anatomy of pituitary gland in fishes, amphibians, reptiles, birds and mammals.
- Origin and Structure of pineal gland
- Structure and biological significance of ultimobranchial gland.

##### UNIT – IV

- Origin and Structure of thyroid gland
- Comparative anatomy of thyroid gland in fishes, amphibians, reptiles, birds and mammals.
- Origin and Structure of parathyroid gland.
- Structure and biological significance of thymus gland.
- Hormonal control of metamorphosis in an anuran amphibians.
- Microanatomy of Islets of Langerhans.

## **UNIT – V**

- Origin and Structure of adrenal gland
- Comparative anatomy of adrenal gland in fishes, amphibians, reptiles, birds and mammals.
- Origin and Structure of testis in mammals.
- Origin and Structure of ovary in mammals.
- Structure of accessory sex organs - male and female.

## **REFERENCES:**

- **Highman, K.C. and Hill, L.** The Comparative Endocrinology of the Invertebrates.
- **Chester-Jones, I., Ingleton, P.M and Phillips, J.G.** (eds.). Fundamentals of Comparative Vertebrate Endocrinology. Plenum Publishing Corp., New York.
- **Bentley, P.J.** Comparative Vertebrate Endocrinology. S. Chand and Company Ltd., New Delhi.
- **Von Euler, U.S. and Heller, H.** (eds.). Comparative Endocrinology. Vol. I & II. Academic Press, London.
- **Gorbman and Bern.** A Text book of Comparative Endocrinology. John Wiley and Sons.

## **II - M. Sc. ZOOLOGY**

### **SEMESTER - III**

#### **ELECTIVE PAPER - III: GENERAL ENTOMOLOGY**

#### **OBJECTIVES**

- *To appreciate the diversity of the Class Insecta and the scope of Entomology.*
- *To study the organization of the external structures that are characteristic of insects.*
- *To study the structure and function of the different systems.*

#### **UNIT - I**

1. Scope and Branches of Entomology.
2. Methods of insect collection and preservation.
3. Outline classification of class Insecta upto order level.
4. Salient features with suitable examples of the following insect orders; Thysanura, Odonata, Orthoptera, Coleoptera, Lepidoptera, Hymenoptera, Diptera.

#### **UNIT - II**

1. Integument - Cuticle, Moulting, Ecdysis.
2. Head - Segmentation, Orientation, Sulci, Tentorium. Mouth parts and modifications
3. Thorax - Segmentation, Wing structure, Venation and Modification.
4. Legs - Structure and Modification.
5. Abdomen – Segmentation, Appendages.

#### **UNIT - III**

1. Digestive system - Structure and modification of gut, Digestive enzymes, Physiology of Digestion.
2. Respiratory system - Structure of Trachea, Spiracles, Air sacs. Terrestrial and Aquatic Respiration.
3. Circulatory system - Organs, Haemolymph, Haemocytes and their functions.
4. Excretory system - Excretory organs, Water regulation.

#### **UNIT - IV**

1. Muscular system - Skeletal muscles, visceral muscles, Energetics of muscle Contraction.

2. Nervous system - Central nervous system, Endocrine organs.
3. Sense organs - Compound eyes, Mechanoreceptors, Chemoreceptors.

#### **UNIT - V**

1. Reproductive system – External genitalia - Reproductive organs in male insect.
2. Reproductive organs in female insect, Types of Ovaries, Oogenesis. Oviposition and egg
3. Special modes of reproduction.
4. Metamorphosis in insects.
5. Pheromones in reproduction.

#### **REFERENCES**

- **Chapman R. F.** Insects; Structure and function.
- **Englemann.** Physiology of Insect reproduction.
- **Imms. A D.** Textbook of Entomology.
- **Mani. M. S.** Entomology.
- **Richards. O. W.** David. Entomology. Vol. I and II.
- **Snodgrass.** Principles of Insect Morphology.
- **Wigglesworth.** Physiology of insects.

## **II - M.Sc. ZOOLOGY**

### **SEMESTER – IV**

#### **PAPER – X: MICROBIOLOGY**

##### **OBJECTIVES**

- *To appreciate the diversity and importance of the microbial kingdom.*
- *To understand the microorganisms that inhabit soil and water.*
- *To study the contribution of microbes in the fields of Food and Dairy Technology, Medicine, Industry and Agriculture.*

##### **UNIT I – SCOPE OF MICROBIOLOGY, CLASSIFICATION, FUNGI AND VIRUSES**

1. Scope of microbiology – Classification of microbes – Five kingdom concept.
2. Yeasts, Fungi and Viruses – Characteristics - Structure - Diseases caused - Economic importance.
3. Bacteriophages – Multiplication – Life cycle.

##### **UNIT II – BACTERIA, BACTERIAL GROWTH AND CONTROL OF MICROBES**

4. Bacteria – Classification – Structure – Reproduction – Economic importance.
5. Bacterial growth – Growth rate – Generation time – Growth curve – Culture techniques.
6. Control of microbes – Sterilization – Disinfection – Chemotherapy – Antisepsis – Mode of action of antimicrobial agents.

##### **UNIT III – SOIL AND AQUATIC MICROBIOLOGY**

7. Soil microbiology – Soil microbes – Nitrogen fixation – *nif* genes – CO<sub>2</sub> fixation and regeneration – degradation of cellulose and lignin – Syntrophism – Soil improvement.
8. Microorganisms in sulfur, phosphorus and iron cycles.
9. Aquatic microbiology – Aquatic pollution and sources – Aquatic microbes – Importance – Microbiology of domestic and waste water – Purification methods – Waste water treatment – Water quality testing.

##### **UNIT IV – FOOD, DAIRY AND MEDICAL MICROBIOLOGY**

10. Food microbiology – Food microbes and sources – Examination – Food spoilage – Food poisoning – Prevention of food poisoning – Food preservation.
11. Dairy microbiology – Microorganisms – Bacteriological examination – Milk borne diseases – Milk preservation – Pasteurization – Sterilization – Dehydration.
12. Medical microbiology – Normal microflora of human body – Pathogenesis, virulence, infection and epidemiology of Diphtheria, Tuberculosis, Cholera, Typhoid, Syphilis and Leprosy.

## UNIT V – INDUSTRIAL AND AGRICULTURAL MICROBIOLOGY

13. Industrial microbiology – Industrial microbes – Fermentation technology – Vinegar – Production of Lactic acid – Amino acids – Hormones – Antibiotics - Vaccines.
14. Agricultural microbiology – Microbes in soil formation and fertility – Biofertilizers – Rhizobium – Azotobacter – BGA – VAM fungi – Azolla – Biopesticides – Silage.

## REFERENCES

- **Ananthanarayanan K &Panickar CKJ**, 1988. Textbook of Microbiology, 3<sup>rd</sup> Edition.
- **Dubey RC &Maheswari DK**, 2004. Textbook of Microbiology. S. Chand & Co. Ltd., New Delhi.
- **Pelczar MJ *et al.***, 1993. Microbiology. McGraw-Hill, New York.
- **Freeman Burrow's** Textbook of Microbiology, 22<sup>nd</sup> Edition. Igaku-Sholin-Saunders International Edition.

## II - M.Sc. ZOOLOGY

### SEMESTER – IV

#### PAPER – XI: ENDOCRINOLOGY – II

##### OBJECTIVES

- *To understand the regulatory mechanisms involved in the secretion of hormones and the mode of action of hormones.*
- *To obtain a thorough understanding of the biological functions of different hormones.*
- *To appreciate the significance of hypo and hyper secretion of endocrine glands.*

##### UNIT – I

- Mechanism of hormone action – peptide and steroid hormone action mechanisms.
- Second messenger hypothesis – cAMP, cGMP, Ca<sup>++</sup> mediated hormone.
- Neuro-endocrine reflex and feedback regulation.
- Biological functions of adenohipophysis and neurohipophysis hormones.
- Disorders due to Hypo and hyper secretion of pituitary hormones and pituitary tumours.

##### UNIT – II

- Synthesis and biological functions of thyroid hormones.
- Disorders due to Hypo and Hyper secretion of thyroid hormones.
- Biological functions of parathyroid hormones.
- Effects of hypo and hyper-parathyroidism.
- Hormonal regulation of calcium and phosphate homeostasis.

##### UNIT – III

- Synthesis and chemistry of the adrenal cortex and medullary hormones.
- Biological functions of cortical and medullary hormones.
- Disorders due to Hypo and hyper secretion of cortical hormones.
- Disorders due to Hypo and hyper secretion of medullary hormones.
- Importance of adreno - cortical and medullary hormone interaction.

#### UNIT – IV

- Biological functions of insulin and glucagon.
- Disorders due to Hypo and hyper secretion of insulin and glucagon.
- Sources and biological functions of gastro-intestinal hormones – gastrin, secretin, cholecystokinin, grelin, motilin and GIP.
- Biological functions of prostaglandins.
- Biological functions of prolactin and hormonal control of lactation.

#### UNIT – V

- Synthesis of steroid hormones.
- Biological functions of testosterone.
- Disorders due to Hypo and hyper secretion of testosterone.
- Biological functions of oestrogen and progesterone.
- Disorders due to Hypo and hyper secretion of oestrogen and progesterone.
- Placental hormones.

#### REFERENCES

- **Goodman, Maurice. H.** Basic Medical Endocrinology. 3<sup>rd</sup> edition. Academic Press, San Diego, USA.
- **Martin, Constance, R.** Endocrine Physiology. Oxford University Press, Oxford.
- **Frieden, Earl and Lipner, Harry.** Biochemical Endocrinology of the Vertebrates. Prentice-Hall Inc., New Jersey.
- **Labhart, Alexis.** Clinical Endocrinology – Theory and Practice. Springer-Verlag, Berlin.
- **Williams, Robert. H.** (Ed.). Textbook of Endocrinology. 6<sup>th</sup> edition. W. B. Saunders Company, Philadelphia.



## II - M. Sc. ZOOLOGY

### SEMESTER - IV

#### ELECTIVE PAPER - IV: APPLIED ENTOMOLOGY

##### OBJECTIVES

- *To study the biology and life cycle of economically beneficial insects.*
- *To understand the significance of insects that are of medical importance.*
- *To understand the biology and economic significance of household and agricultural insect pests.*
- *To appreciate the contribution of biological pest control methods.*

##### UNIT - I

Biology, Life cycle and Economic importance of,

1. Honey bee (*Apis indica*).
2. Silk worm (*Bombyx mori*).
3. Lac insect (*Tachardialacca*).
4. Helpful insects – Pollinators, Soil builders, Scavengers, Medicinal insects.

##### UNIT - II

1. Insect pests- Definition, Kinds of pest, Pest outbreak.
2. Pest Surveillance, Forecasting and Monitoring.
3. Insect vectors of various diseases like Malaria, Dengue, Chickungunia, Filariasis, and Yellow Fever and their control measures.
4. Pest of domestic animals - Cattle, Fowl, Dog.
5. House hold pest – Cockroach, Ants, Termites.

##### UNIT - III

Life history, Nature of damage and Control measures of any two major pests of,

1. Paddy, Cotton.
2. Groundnut, Coconut.
3. Brinjal, Tomato.
4. Mango, Banana.
5. Sugarcane, Teak.

##### UNIT - IV

1. Pest control methods - Natural, Topographic, Climatic, Legal methods.
2. Physical, Mechanical, Cultural methods.
3. Chemical control - Organic, Inorganic, Synthetic insecticides and mode of their action.
4. Fumigants and pest control.
5. Pesticides and the environment.

6. Physico-chemical adaptations in insects.

#### **UNIT - V**

1. Biological pest control- Parasites, Parasitoids, Pathogens, Predators.
2. Insect Attractants, Repellants, Chemosterilants, Antifeedants
3. Ionizing radiation, Electromagnetic energy, Genetic manipulation in insect control.
4. Integrated Pest Management.
5. Botanical insecticides - Neem, Pyrethrum, Nicotine.

#### **REFERENCES**

- **B. Vasantharaj David and J. Kumaraswamy.** Elements of Economic Entomology.
- **David B, Anantha Krishnan and Nayar.** Entomology.
- **N. T. Krishnan.** Economic Entomology.
- **P.G. Fenemore and Alka Prakash.** Applied Entomology. Wiley Eastern Ltd, New Delhi.
- **Pradhan, S.** Insect Pest of Crops. National Book Trust of India, New Delhi.
- **T. V. Ramakrishnanand Ayyar.** South Indian Insects.

## **II - M.Sc. ZOOLOGY**

### **SEMESTER – III & IV**

#### **PRACTICAL – III**

**(Papers covering: Paper – VII: Developmental Biology, Paper – VIII: Immunology, Paper – X: Microbiology and Paper – IX & XI – Endocrinology)**

#### **Experimental Embryology:**

- Regeneration of tail in amphibian tadpoles.
- Vital staining and mounting of chick embryo at various stages.
- A study of early stages of chick embryo development (96 hours).

#### **Immunology and Microbiology:**

- Dissection to expose primary and secondary lymphoid organs of rat / mouse
- Micro – measurement of yeast, paramecium, RBC and WBC.
- Gram staining of bacteria.
- Hanging drop method to observe live micro-organisms.
- Identification of bacteria in buccal smear.
- Preparation of microbial culture media.
- Types of micro-organism: Observation of the structural characteristics and economic importance of bacteria, algae and fungi.

#### **Endocrinology:**

- Dissection to expose the endocrine glands in the following animals - cockroach, fish.
- Observation of slides of endocrine glands.
- Effect of thyroxine injection on animal (metamorphosis).
- Effect of adrenaline on respiration of fish.
- Parabiosis in insects.

**Spotters:**

- Gram's stain
- Autoclave
- Laminar Air Flow chamber
- Loop
- Needle
- Western Blot
- ELISA
- Widal kit
- VRDL kit
- Anti – A, B & D.

**II - M.Sc. ZOOLOGY**  
**SEMESTER – III & IV**  
**PRACTICAL – IV**

**(Papers Covering: Elective Papers – III & IV – Entomology)**

- ❖ Identification of the following insect orders and their families using dichotomous keys:-
  - Apterygota
  - Orthoptera
  - Lepidoptera
  - Coleoptera
  - Hemiptera
  - Diptera
  - Hymenoptera
  - Odonata
  
- ❖ **Dissections** in common South Indian insects of the order mentioned above (one or two representatives from each order):
  - Digestive system
  - Nervous system
  - Reproductive system
  
- ❖ **Mountings:**
  - Mouth parts – Honey bee, Bed bug, Mosquito, House fly, Zonabris and Lepisma.
  - Ovaries – Grasshopper and Cockroach.
  
- ❖ **Physiology:**
  - Qualitative study of digestive enzymes of an insect.
  - Study of haemocyte in the haemolymph of cockroach.
  - Qualitative estimation of protein in the haemolymph of an insect.
  - Qualitative estimation of carbohydrate in the haemolymph of an insect.
  - Qualitative estimation of fat in the haemolymph of an insect.

- ❖ Studies of different types of damage caused by insect pests.
- ❖ Periodical field collection, preservation and identification of insects.
- ❖ Slide preparation – minimum of 10 permanent mount slides.
- ❖ **Submission:**
  - Tour report
  - Insect collection – Insect pests and damage material.
  - Slides – 10 nos. (Permanent mount).