I - B. Sc. ZOOLOGY

SEMESTER - I

CORE PAPER - I: NON CHORDATA

OBJECTIVES

- *To appreciate the diversity of life on earth with respect to Non-Chordates.*
- *To understand the general characteristics of the different Phyla as exemplified in representative type studies.*
- *To study certain morphological attributes and physiological processes that are distinct and significant to each Phyla.*

UNIT – I

PHYLUM: PROTOZOA

Class: Sporozoa – ***Plasmodium.***

Locomotion in Protozoa.

Reproduction in Protozoa.

Economic importance of Protozoa with reference to parasitic Protozoans.

PHYLUM: PORIFERA

Class: Calcarea – ***Leucosolenia.***

Canal system in sponges.

Spicules in sponges.

Economic importance of sponges.

UNIT – II

PHYLUM: COELENTERATA

Class: Hydrozoa – ***Obelia.***

Polymorphism in Coelenterates.

Coral reefs in Coelenterates.

Economic importance of Coelenterates.

PHYLUM: PLATYHELMINTHES

Class: Trematoda – ***Fasciola hepatica.***

Parasitic adaptation in Platyhelminthes.

UNIT - III

PHYLUM: ASCHELMINTHES

Class: Nematoda – ***Ascaris lumbricoides.***

Nematode parasites of man and domestic animals- occurrence and mode of transmission in (excluding life history) ***Ascaris, Ancylostoma, Enterobius, Wuchereria, Dracunculus.***

PHYLUM: ANNELIDA
Class: Hirudinea – ***Leech.***
Excretion in Annelida.
Adaptive radiation in Polychaetes.

UNIT - IV
PHYLUM: ARTHROPODA
Class: Insecta – **Cockroach.**
Crustacean larva.
Mouthparts in insects.
Economic importance of Arthropods.

UNIT - V
PHYLUM: MOLLUSCA
Class: Gastropoda – ***Pila.***
Foot in Mollusca.
Economic importance of Mollusca.

PHYLUM: ECHINODERMATA
Class: Asteroidea – **Starfish.**
Water vascular system in Echinodermata.
Echinoderm larvae.

TEXT BOOK

- **Ayyar, M. Ekambaranatha.** 1973. A Manual of Zoology, Part I. Invertebrata. S. Viswanathan Pvt. Ltd. 842 pages.

REFERENCE BOOKS

1. **Jordan, E.L. and Verma, P.S.** 2000. Invertebrate Zoology. S. Chand & Co. 857 pages.
2. **Kotpal, R.L.** 2000. Modern Textbook of Zoology – Invertebrates. Rastogi Publ. 807 pages.
3. **Barnes, Robert D.** 1981. Invertebrate Zoology. Saunders College Publ. 1089 pages.

I - B.Sc. ZOOLOGY

SEMESTER - II

CORE PAPER - II: CHORDATA

OBJECTIVES

- *To understand the diversity of Chordates and its outline systematics.*
- *To study the general characteristics of the different Classes and the organization of the representative types.*
- *To understand the features that are unique to the different Chordate Classes.*

UNIT - I

Outline classification of Phylum Chordata.
General organization of ***Amphioxus*** (excluding endoskeleton) and its affinities.
General characters of Class Pisces.
General organization of **Shark** (excluding endoskeleton).
Accessory respiratory organs in fishes.

UNIT - II

General characters of Class Amphibia.
General organization of **Frog** (excluding endoskeleton).
Parental care in Amphibians.

UNIT - III

General characters of Class Reptilia.
General organization of ***Calotes*** (excluding endoskeleton).
South Indian poisonous and non- poisonous snakes.
Mechanism of snake bite and treatment for snake bite.
Sphenodon - a living fossil.
An account of Dinosaurs.

UNIT - IV

General characters of Class Aves.
General organization of **Pigeon** (excluding endoskeleton).
An account of Archaeopteryx.
Flight adaptation in birds.
Migration in birds.

UNIT - V

General characters of Class Mammalia.
General organization of **Rabbit** (excluding endoskeleton)**.**
Salient features of Monotremes and their affinities.
Salient features of Marsupials.
An account of aquatic mammals and their adaptation.
Dentition in mammals.

TEXT BOOK

- **M. Ekambaranatha Ayyar,** 1973. A Manual of Zoology. Part II. S. Viswanathan Pvt. Ltd., Madras.

REFERENCE BOOKS

1. **J.Z. Young,** 2006. The Life of Vertebrates. The Oxford University Press, New Delhi.

2. **R.L.Kotpal,** 2000. Modern Textbook of Zoology, Vertebrates. (Rastogi Publ., Meerut). 632 pages.
3. **E.L. Jordan & P.S. Verma,** 2010. Chordate Zoology. S. Chand & Co.. 1092 pages.

I – B.Sc. ZOOLOGY

CORE PRACTICAL – I

SEMESTER - I & II

(Paper Covering: Paper – I: NON – CHORDATA and Paper – II: CHORDATA)

SPOTTERS

CLASSIFY GIVING REASONS

1. *Paramecium* - Entire.
2. Ascon sponge - Entire
3. *Gorgonia* - Entire.
4. Liver fluke - Entire.
5. *Ascaris* - Entire.
6. Earthworm - Entire.
7. *Penaeus* - Entire.
8. *Loligo* - Entire.
9. Star Fish - Entire
10. Ascidia - Entire.
11. Shark - Entire.
12. Frog - Entire.
13. *Calotes* - Entire.
14. Pigeon - Entire.
15. Rat - Entire.

DRAW LABELLED SKETCH

1. Obelia – Colony.
2. Frog – Skull (Dorsal and Ventral view).
3. Frog – Girdles (Pectoral and Pelvic).
4. Carapace and Plastron.
5. Pigeon – Quill feather.
6. Rabbit – Skull (Dorsal and Ventral).
7. Rabbit – Girdles (Pectoral and Pelvic).

BIOLOGICAL SIGNIFICANCE

1. Sponge – Gemmule.
2. Nauplius Larva.
3. Nautilus.
4. Chamaeleon.
5. Bat.

DESCRIPTIVE NOTES

1. Starfish.
2. Exocoetus.
3. Draco.
4. Cobra.
5. Owl.

RELATE STRUCTURE AND FUNCTION

1. Nereis – Parapodium.
2. Scorpion – Book Lungs.
3. Rabbit – Dentition.
4. Dog – Dentition.
5. Duck – Palate.

DISSECTIONS

1. Earthworm – Digestive and Nervous systems.
2. Prawn – Appendages.
3. Cockroach – Morphology, Digestive system, Nervous system and Reproductive systems.
4. Fish – Morphology and Digestive system.

MOUNTINGS

1. Cockroach – Mouth parts.
2. Honey bee - Mouth parts and sting.
3. Types of scales.
4. Earthworm – Body setae.

II - B.Sc. ZOOLOGY

SEMESTER - III

CORE PAPER – III: CELL BIOLOGY

OBJECTIVES

- *To underline the central role played by Cell Biology in current biological science.*
- *To understand the organization and functions of the different cell organelles.*
- *To understand cell cycle, cell division, cell differentiation (stem cells) and cell aging.*
- *To study the nature, expression and regulation of the genetic materials at the molecular level.*

UNIT – I

Cell – Cell theory, Ultra structure of animal cell – structure, composition and functions – cell components – Plasma membrane – Endoplasmic reticulum – Ribosomes, Golgi complex, Lysosomes, Centrioles and Mitochondria.

UNIT – II

Nucleus – Ultrastructure, Composition and Function – Nuclear Membrane, Nucleoplasm – Chromosomes – Polytene and Lampbrush Chromosomes, Giant Chromosomes – Nucleolus.

UNIT – III

DNA – Semi conservative replication, Mechanism and Enzymology of DNA replication, Structure and Functions of DNA.

RNA – Structure, Types (mRNA, tRNA, rRNA), Functions – Protein Synthesis.

UNIT – IV

Cell cycle and Cell division – Amitosis, Mitosis and Meiosis and their significance.

Cancer Cells - Distinction between normal cells and cancer cells – Cytological changes in cancer cells.

UNIT – V

Stem Cells – Embryonic and Adult stem cells – Characteristics of stem cell – Applications of Stem cells. Senescence (Aging) – Apoptosis in ***C. elegans.***

TEXT BOOK

- **P.S. Verma & Agarwal**. 2001. Concepts of Cell Biology. S. Chand & Co.

REFERENCE BOOKS

1. **Ajay Paul**., 2011. Cell and Molecular Biology. Books and Allied Pvt, Kolkata.
2. **Powar, C.B**., 2002. Cell Biology. Himalaya Publishing House.
3. **Cohn, N.S**., 1979, Elements of Cytology, Freeman Book Co., New Delhi.

II - B.Sc. ZOOLOGY

SEMESTER – III

SKILL BASED SUBJECT – PAPER – I: VERMITECHNOLOGY

OBJECTIVES

- *To appreciate the role of Earthworms and the concept of Vermitechnology.*
- *To understand the Earthworm- types, classification, organization and lifecycle.*
- *To study all aspects related to Vermicomposting and the economics of Vermiculture.*

UNIT - I

Vermitechnology – Definition – History.

Earthworms – Classification.

Morphological and Anatomical Characteristics of Earthworms.

Lifecycle of ***Eudrilus eugeniae*** and ***Lampito mauritii***.

UNIT - II

Earthworm – Ecological Types.

Earthworms for Vermiculture.

Sampling of Earthworms.

Earthworm – Collection – Transport – Storage.

UNIT - III

Composting and Vermicomposting.

Vermicomposting Materials.

Types of Vermicomposting.

Factors affecting Vermicomposting.

UNIT - IV

Vermicompost – Harvesting and Storage.

Vermicast and Vermiwash.

Vermiprotein and Earthworm paste.

Earthworm parasites and predators.

UNIT - V

Role of Earthworms in Agriculture.

Uses of Earthworms in Medicine.

Earthworm and Pollution Control.

Investment – Cost Marketing Awareness – NABARD – KVIC.

REFERENCE BOOKS

- **U.S. Bhawalkar and V.U. Bhawalkar**. 1992. Vermi Biotechnology, Bhawalkar Earthworms Research Institute, Pune, India.
- **Sultan Ismail,** 1997. Vermicology – The Biology of Earthworm, Orient Longman Limited, Chennai.
- **L.S. Ranganathan**. 2006. Vermitechnology from soil Health to Human Health, Agrobios (India), Agro House, Chopasani Road, Jodhpur, 342002.
- **R. Ramalingam**. 2007. Mann Puzhu Valarpu.
- **P.K. Gupta**. 2005. Vermicomposting for Sustainable Agriculture, Second Revised Edition . Publisher- Dr.Updesh Purohit for Agrobios (India), Jodhpur.

II - B.Sc. ZOOLOGY

SEMESTER - IV

CORE PAPER - IV: ANIMAL PHYSIOLOGY

OBJECTIVES

- *To understand the structure of the different organ systems in man/mammals.*
- *To understand the mechanisms involved in the functioning of the different systems.*
- *To study certain disorders that arise as a consequence of physiological malfunction.*

UNIT – I

Nutrition – Food requirements – Balanced Diet.

Digestive enzymes.

Digestion and Absorption.

UNIT – II

Respiration – Respiratory pigments and functions, Respiratory quotient, Bohr's effect, Chloride shift.

Blood – Composition, Properties and Functions.

Human Cardiac Cycle, Rhythm – Origin and Regulation of Heart Beat – ECG – BP – Heart Problems and coronary circulation.

UNIT – III

Excretion – Kidney – Structure and Function, Mechanism of Urine formation, Kidney Failure.

Osmoregulation in mammals.

UNIT – IV

Nervous tissue – Neuron – Structure, types of neurons, Nerve impulse.

Synapse – Synaptic transmission, Neurotransmitters.

Receptors – Photoreceptor – Mammalian Eye – Physiology of vision.

Phonoreceptors – Mammalian Ear and Phonoreception in bat.

UNIT – V

Endocrine glands – Structure, secretions and functions of all endocrine glands of vertebrates.

TEXT BOOK

- **Verma, Tyagi and Agarwal**. 1986. Animal Physiology . Chand & Co., New Delhi.

REFERENCE BOOKS

1. **William. S. Hoar**. 1976. General and Comparative Physiology, Prentice Hall of India Pvt. Ltd., New Delhi-110 001.
2. **Wood. D. W.** 1983. Principles of Animal Physiology. 3rd edition.
3. **Prosser and Brown.** 1985. Comparative Animal Physiology. Satish Book Enterprise, Agra-282 003.

II - B.Sc. ZOOLOGY

SEMESTER – III & IV

CORE PRACTICAL - II

(Paper Covering: Paper – III: CELL BIOLOGY and Paper – IV: ANIMAL PHYSIOLOGY)

CELL BIOLOGY

Preparation of blood smear and observation of cell types.

Morphology of chromosomes from a study of the squash preparation of testis of Cockroach and Onion root tip.

Chromosomal studies in Drosophila larva.

ANIMAL PHYSIOLOGY

Survey of digestive enzymes in Cockroach.

Study of salivary amylase activity in relation to temperature and pH in human saliva.

Estimation of oxygen consumption in freshwater fish and calculation of unit metabolism.

Qualitative detection of excretory products.

Preparation of haemin crystals.

Enumeration of red blood corpuscles using haemocytometer.

Estimation of bleeding time and clotting time of blood.

SPOTTERS - CELL BIOLOGY

Study of the histology of various tissues – epithelial, muscle, bone, nervous and fluid tissues.

Stages of Mitosis and Meiosis.

Microscope – Compound and Binocular.

Centrifuge.

SPOTTERS -PHYSIOLOGY

Haemocytometer.

Sphygmomanometer.

II – B. Sc. ZOOLOGY

SEMESTER - IV

SKILL BASED SUBJECT - PAPER - II: CLINICAL LABORATORY TECHNIQUES

OBJECTIVES

- *To appreciate the immense practical scope of the subject.*
- *To understand the laboratory practices and laboratory requirements.*
- *To study the procedures involved in Haematology, Bacteriology and Parasitology.*
- *To understand the significance of the examination of body fluids and exudates.*

UNIT - I

Introduction

Scope of Clinical Laboratory Techniques.

Laboratory instruments – Haemocytometer, Haemoglobinometer, and Urinometer.

Cleaning, Sterilization and Disposal of infected materials.

First – aid in laboratories.

Microscopes – Dissection microscope, Compound microscope.

UNIT - II

Haematology

Collection of Blood Sample, Isolation of plasma and serum.

Enumeration of Total RBC and Estimation of Haemoglobin.

Enumeration of Total WBC and Differential Leucocyte Count.

Anticoagulants, BT, CT and ESR.

ABO Blood grouping, Rh typing, Cross matching.

UNIT - III

Bacteriology

Morphology of Bacteria

Culture preparation and staining of microorganisms.

Typhoid, Cholera and Meningitis.

Motility test for bacteria – Hanging drop method.

UNIT - IV

Examination of stool, urine and other fluids

Gastric juice analysis.

Liver function Test.

Examination of stool specimen

Examination of urine.

Examination of seminal fluid.

Examination of pus and sputum.

UNIT - V

Human Parasites – Diseases, symptoms, diagnosis and treatment

Malarial parasite, Leishmania and Trypanosoma.

Intestinal Round worm and Tissue Round worm.

Flukes and Tape worm.

TEXTBOOK

Kani, L. Mukerjee. Medical Laboratory Technology, Tata McGraw Hill Publishing Co., Ltd., New Delhi.

REFERENCE BOOKS

1. **Samuel, K.M.** Notes on Clinical Lab Techniques. Pub. M.K. Gopalan, Chrompet, Chennai.
2. **Ramnik Sood**, M.D. Medical Laboratory Technology – Jaypee Brothers, Medical Publishers (p) Ltd., New Delhi.
3. **Arumugam, N**. Microbiology (General and Applied). Saras Publications.

III - B. Sc. ZOOLOGY

SEMESTER - V

CORE PAPER - V: IMMUNOLOGY AND MICROBIOLOGY

OBJECTIVES

- *To understand the concept of immunity and its constituent types.*
- *To study the lymphoid organs, the cells of the immune system and the effector molecules namely, antigens and antibodies.*
- *To study the clinical manifestations of immunological disorders.*
- *To appreciate the diversity of microbes and significance of certain microbes that are associated with man.*

UNIT - I

1. Immunity- Innate immunity – Physical, Mechanical and Biochemical factors – Cellular factors –Genetic factor
2. Acquired immunity – Natural – Artificial –Active – Passive immunity
3. Cell mediated immunity

UNIT - II

4. Lymphoid organs – Primary Lymphoid organs – Thymus – Bursa of Fabricius –Bone marrow
5. Secondary Lymphoid organs – Lymph node – spleen – MALT – Payer's patches Tonsils
6. Cell of the immune system – Lymphoid lineage –Myeloid lineage

UNIT- III

7. Antigens –haptens - chemical nature of antigens – Antigenic determinants – factors of antigenicity
8. Antibody – Immunoglobulin – Types and functions of Immunoglobulins – Structure and biological properties of Immunoglobulin G.
9. Immunizing agents – Vaccines – Types of Vaccines-Common Vaccines
10. Auto immune disorders – Definition, Characteristics –Lupus Erythematosus, Rheumatoid Arthritis.

UNIT - IV

1. Classification – Whittaker's five kingdom concept
2. Structure and Reproduction of Bacteria
3. Bacterial disease in Man –Typhoid , Cholera, Tuberculosis
4. Structure and Reproduction of T_4 Phage.
5. Viral disease in Man – AIDS, Polio, Rabies

UNIT - V

6. Structure and economic importance of yeast
7. Sterilization
8. Culture media and culture techniques
9. Microbiology of food poisoning

TEXT BOOK

- **Dulsy Fathima & Arumugam N**. 1988. Immunology, Saras Publications.

REFERENCE BOOKS

1. **Ananthanarayanan, K. & Jayaram Panicker, C.K**. 1988. Text book of Microbiology, 3rd Edition.
2. **Dasgupta. A.** 1982. Morden Immunology, 2nd Edition, Jaypee Brothers, Medical Publications, New Delhi.
3. **Pelczar, M.J**. *et al*. 1993. Microbiology, McGraw Hill, New York.
4. **Stewart, F.S.** 1968. Bacteriology and Immunology for students of Medicine. 9th edition. ELBS.
5. **Freeman Burrows**. Text Book of Microbiology. 22nd Edition, Igaku-Shoin-Saunders International Edition.

III - B. Sc. ZOOLOGY

SEMESTER - V

CORE PAPER - VI: BIOCHEMISTRY & BIOPHYSICS

OBJECTIVES

- *To understand the structure and metabolism of biologically significant molecules.*
- *To appreciate the contribution of enzymes and vitamins to life processes.*
- *To introduce the tools and techniques available for the study of the biochemical and biophysical attributes of life.*

BIOCHEMISTRY

UNIT - I

1. Carbohydrates – Classification and Structure (Glucose).
2. Metabolism of Glucose – Glycolysis, oxidative decarboxylation, Kreb's cycle, Production of ATP.
3. Glycogenesis, Glycogenolysis, Gluconeogenesis.

UNIT - II

4. Protein – Structure, Amino acids – Properties, Peptide bond formation.
5. Protein metabolism – Transamination & Deamination.
6. Lipid – Classification, Structure and properties of triglycerides, β-oxidation of fatty acids and Intermediary metabolism.

UNIT - III

7. Enzymes – Classification, Mechanism of enzyme action, Inhibition, Factors affecting enzyme action, Co-enzymes
8. Vitamins – Types, Sources, Functions and Deficiency diseases.

BIOPHYSICS

UNIT - IV

1. Microscopy – Principle, Structure and application of Compound microscope, Transmission Electron Microscope and Scanning Electron Microscope.
2. Centrifugation.
3. Cell fractionation methods.

UNIT - V

4. Radio isotope Trace techniques and Auto radiography.
5. Chromatography – Principles and applications of Paper Chromatography.
6. Electrophoresis – Principles and applications of PAGE Electrophoresis.

TEXT BOOKS

- **U. Satyanarayana & U. Chakrapani**. Essentials of Biochemistry. 2nd Edition.
- **Dr. S. Palanichamy & Dr. M. Shunmugavelu.** Principles of Biophysics.

REFERENCE BOOKS

1. **Mukhtar Ahmed**. 1993. Text book of Modern Biochemistry. Vol. I. Oxford & IBH Publishing Co. Pvt. Ltd.
2. **Ambika Shanmugam**. 1998. Fundamentals of Biochemistry for Medical Students.
3. **Lehninger, A.L.** 1981. Biochemistry. Worth Publishers .

III – B. Sc. ZOOLOGY

SEMESTER – V

CORE PAPER VII – BIOTECHNOLOGY

OBJECTIVES

- *To introduce the tools and techniques employed in genetic engineering.*
- *To understand gene cloning procedures in prokaryotes and eukaryotes.*
- *To study the techniques of animal cell culture, organ culture, animal cloning and assisted reproduction.*
- *To appreciate the contribution of biotechnology in medicine, agriculture, industry, food science and environmental protection.*

UNIT – I: Molecular Tools of Genetic Engineering

Scope of Biotechnology – Biotechnology tree.

Enzymes

Exonuclease, Restriction endonuclease, Reserve transcriptase, Ligase, Alkaline phosphatase, Polymerase – Klenow fragment.

Cloning Vectors

Bacterial vectors – Plasmid (pBR322), Bacteriophage (λ phage), Cosmid (pJB8); Animal viral vector – SV40; Yeast vector – Yac vector; Shuttle vector.

UNIT - II: Techniques in Genetic Engineering

Probes – Construction and Labelling (Radioactive – Random primed method, Non – radioactive – Biotinylation method).

Blotting Technique – Southern Blotting.

DNA Sequencing Technique – Sangar and Coulson method, DNA Microarray.

DNA Amplification Technique – PCR - Technique and Application.

UNIT – III: Gene Cloning

In Prokaryotes

Preparation of desired DNA (Restriction digestion, c DNA synthesis, Chemical synthesis- Phosphoramidite method).

Insertion of r DNA (Linkers, Adaptors, Homopolymer tailing).

Introduction of recombinant DNA (Transformation, Transduction, Electroporation).

Selection of rDNA (Direct selection, Immunochemical method – RIA, Colony hybridization).

In Eukaryotes

Introduction of r DNA (Transfection, Liposome - mediated gene transfer, Particle bombardment, Virus vector method, Microinjection).

UNIT - IV: Animal Cell Culture and ART

Cell culture – Steps involved in the cell culture technique.

Organ culture – Methods and Application.

Assisted Reproductive Technology in man – Artificial insemination (AI), *In vitro* fertilization (IVF), Embryo transfer (ET), Gamete intra – fallopian transfer (GIFT), Zygote intra – fallopian transfer (ZIFT), and Intra-cytoplasmic sperm injection (ICSI).

Animal Cloning – Nuclear Transfer Method – Cloning in Sheep (DOLLY).

UNIT – V: Applied Biotechnology

Medical Biotechnology – Production of - Hepatitis B Vaccine, Monoclonal Antibodies, Human insulin.

Agricultural Biotechnology – Production of – Bio-fertilizer (*Rhizobium*), Bio-insecticide (*Bacillus thuringiensis*).

Industrial Biotechnology – Production of - Antibiotic (Pencillin), Alcohol (Ethanol).

Food Biotechnology – Production of - SCP (*Spirulina*), Mushroom (White Button).

Environmental Biotechnology – Biodegradation – Super Bug.

TEXTBOOK

- **Biotechnology – V. Kumaresan**, Saras Publication, Kanyakumari, Edition (2009).

REFERENCE BOOK

- **Biotechnology – U. Satyanarayana**, Books and Allied (P) Ltd, Kolkata, Edition (2005).

III - B.Sc. ZOOLOGY

SEMESTER - V

CORE PAPER - VIII: EVOLUTION

OBJECTIVES

- *To introduce the concept of origin of life.*
- *To critically evaluate the theories of evolution in the light of available evidences.*
- *To study human evolution from the biological and cultural perspectives.*
- *To understand the laws and concepts associated with evolution.*

UNIT - I

Origin of life

1. Theories of Origin of life.

2. Biochemical origin.

3. Geological time scale.

4. Zoogeographic realms.

UNIT - II

Evidences of evolution

1. Morphological evidences.

2. Embryological evidences.

3. Physiological evidences.

4. Paleontological evidences.

UNIT - III

Theories of evolution

1. Lamarckism.

2. Darwinism.

3. Neo Darwinism.

4. Mutationism.

UNIT - IV

Human evolution

1. Biological evolution.

2. Fossil record of human evolution.

3. Cultural evolution.

4. Future evolution.

UNIT - V

Concepts of evolution

1. Hardy - Weinberg law.

2. Speciation.

3. Isolation.

4. Ariyalur fossil system.

TEXT BOOK

- Organic Evolution - **Dr. N. Arumugam**, Saras Publication.

REFERENCE BOOKS

1. **Pat Willmer**, 1990. Invertebrate relationship, Cambridge University Press, 1990.
2. **Colbert, E.H**., Evolution of Vertebrates, Wiley Eastern Ltd. , New Delhi.
3. **Romer, A.S**., Vertebrate Paleontology, Cambridge University Press.
4. **Abraham, J.C.B**., 1987. Evolution: A laboratory Manual. Macmillan India Ltd.,Madras.

III – B. Sc. ZOOLOGY

SEMESTER – V

SKILL BASED SUBJECT – PAPER – III: ORNAMENTAL FISH CULTURE

OBJECTIVES

- *To introduce the aquarium fishes*
- *To study the steps involved and requirements in the establishment of an aquarium.*
- *To understand the breeding, feeding and diseases that affect aquarium fishes.*
- *To understand the economics of ornamental fish culture.*

UNIT - I

Introduction to ornamental fish culture.
Taxonomy of aquarium fishes – marine – fresh water, tropical and cold water species.
Water tolerance.

UNIT - II

Design and construction of ornamental fish tank.
Aquarium setting.
Aquarium accessories – natural and artificial aquatic plants, insects, aerators and heaters.
Water quality management.

UNIT - III

Commercially important ornamental fishes.
Selection of species.
Breeding of live bearers.
Breeding of egg layers.

UNIT – IV

Culture of live feeds and Methods of preparation of artificial feeds.
Common diseases and their control.

- Viral – Carp pox, Spring Viraemia of carp (SCV)
- Bacterial – Fin rot and Fish Dropsy
- Fungal – Saprolegnia and Icthyophonus hoferi
- Protozoan – White spot disease (Ich) and Velvet disease.

UNIT - V

Transportation of ornamental fishes.
Economics of ornamental fish culture – setting up of an export oriented unit – financial viability - financial assistance – NABARD.

TEXT BOOK

- Home Aquarium – **Thara Devi C. S. and Jaya Shree K. V**., Saras Publication, Nagarkoil.

REFERENCE BOOK

- Aquaculture. 2008. **N. Arumugam**. Saras Publication.
- Aquaculture. 2005. **S. Venugopal**. Pointer Publishers.
- Textbook of Aquaculture. 2008. B. **Ahilan , N. Felix and R. Santhanam.** Daya, Public Delhi.
- General and Applied Icthyology, 2006. **S. K. Gupta and P. C. Gupta.** S. Chand & Co. Ltd.
- Hand book of Fisheries and Aquaculture Technology. **K.R. Gupta**. Asia PACIFIC Business Press.
- Aquaculture. **T. N. R. Pillai**.

III – YEAR
SEMESTER - V
NON – MAJOR ELECTIVE - PAPER – I: BIOFARMING- I
(For Non – Zoology students only)

OBJECTIVES

- *To introduce the potential avenues for the commercial application of Zoology.*
- *To understand the basics of Apiculture, Sericulture, Vermiculture, Mushroom culture and Biofertilizer production.*

UNIT – I: APICULTURE

Honey bee species in Apiculture, Social organization – Life history.
Bee keeping – Modern methods – Appliances – Hive and other accessories.
Bee pasturage –Requirement and Hiving of bees. Management of an Apiary. Economics and disease of honey bees. Honey-properties, extraction, preservation and uses of honey. Bee wax and its uses.

UNIT – II: SERICULTURE

Silkworm varieties. Employment in Sericulture. Mulberry silkworm – brief biology and life cycle. Cultivation of mulberry plants. Rearing of Silkworm. Major disease of Silkworm.
Silk - Properties and uses.

UNIT – III: VERMICULTURE

Types of earth worms employed in vermicomposting.
Methods of vermicomposting. Economic importance of vermicomposting.
Economic importance of Vermiculture.

UNIT – IV: MUSHROOM CULTURE

Cultivable edible mushrooms. Features of poisonous mushrooms. Cultivation of oyster mushroom, milky mushroom and white button mushroom. Diseases and storage.
Economic importance – Nutritive and medicinal value and other uses

UNIT – V: BIOFERTILIZERS

Bacteria – Rhizobium, Azotobacter, Azospirillum, Blue green algae, Mycorrhizal fungi – Azolla – Productions and Applications.

TEXT BOOKS

1. Economic Zoology- G**. S. Shukla and V.B Upadhyay**
2. Economic and Applied Entomology, **A. Kumar and P. M.Nigam**.
3. Text book of Zoology. Invertebrate's Animal diversity – I. **R. L. Kotpal.**
4. **Sultan Ismail**, 1997. Vermicology – The Biology of Earthworm Orient Longman Limited, Chennai.

III - B.Sc. ZOOLOGY

SEMESTER - VI

CORE PAPER - IX - DEVELOPMENTAL BIOLOGY

OBJECTIVES

- *To understand the process of gametogenesis and fertilization.*
- *To do a comparative study of cleavage and gastrulation in frog, chick and pig.*
- *To understand certain phenomena integral to developmental biology.*

UNIT-I

1. Spermatogenesis and types of sperms.

2. Oogenesis, types and classification of eggs.

3. Types and process of fertilization.

4. Physiological events during fertilization.

5. Theories of fertilization.

UNIT-II

6. Planes of cleavage.

7. Patterns of cleavage.

8. Cleavage in Frog.

9. Cleavage in Chick.

10. Cleavage in Pig.

UNIT-III

11. Morphogenetic movements of gastrulation.

12. Gastrulation in Frog.

13. Gastrulation in Chick.

14. Gastrulation in Pig.

UNIT-IV

15. Organizer - Types, nature of inductors, mechanism of induction.

16. Organogenesis – Development of Brain.

17. Regeneration – Types of regeneration, Origin of blastema cells, Events in regeneration.

UNIT-V

19. Extra-embryonic membranes in Chick.

20. Placentation in mammals.

21. Infertility and Birth control.

TEXT BOOK

- Chordate Embryology – **P. S. Verma, V. K. Agarwal & B. Tyagi**.
- A Text Book of Embryology – **N. Arumugam.**

REFERENCE BOOKS

1. **Balinsky, B. I**., An Introduction to Embryology, Saunders and Co.,

2. **Berrill, N. J**. Developmental Biology, Tata McGraw Hill.

III - B.Sc. ZOOLOGY

SEMESTER - VI

CORE PAPER – X: GENETICS

OBJECTIVES

- *To appreciate the relevance of classical genetics.*
- *To gain a molecular level understanding of genetics.*
- *To understand certain genetic disorders and diagnostic methods.*

UNIT – I

1. Mendelian laws – Monohybrid and Dihybrid experiments.
2. Genic interactions – Complementary genes – Supplementary genes (Coat color in mice) – Epistasis (Dominant & Recessive) – Complete dominance – Incomplete dominance – Codominance (Coat color in cattle).

UNIT – II

3. Multiple alleles – definition – ABO blood groups – Rh factor.
4. Linkage – Coupling and repulsion – Types of linkage – Linkage in Drosophila.
5. Crossing over – Mechanism – Tetrads – Theories – Significance of crossing over.

UNIT – III

6. Sex determination – Theories – Chromosomal theory – Theory of heterogamesis – Genic balance theory – Barr body - Male haploidy – Gynandromorphs – Cytological basis of sex determination – Environmental sex determination – Hormonal theory – Free martins.
7. Sex-linked inheritance in man – Haemophilia and colour blindness.

UNIT – IV

8. DNA as genetic material – Griffith's experiment only.
9. Genetic code.
10. Gene concept – Cistron, Muton, Recon.
11. Gene regulation in Prokaryotes.
12. Chromosomal aberrations - Gene mutation – Mutagens.

UNIT – V

13. Non-disjunction – Klinefelter's syndrome – Turner's syndrome – Down's syndrome.
14. Inborn errors of metabolism – Phenylalanine metabolism - Sickle cell anemia.
15. Eugenics – Euthenics – Euphenics.
16. Karyotype and Idiogram – Amniocentesis.

TEXT BOOK

- **PS Verma & VK Agarwal**, 2005. Genetics. S Chand & Co.

REFERENCES:

1. RP Meyyan, 2001. Genetics. Saras Publications.
2. Klug & Cummings, 1983. Concepts of Genetics. Merrill Pub Com., Ohio.
3. PK Gupta. Genetics. Rastogi Publications.

III - B.Sc. ZOOLOGY

SEMESTER - VI

CORE PAPER- XI: ECOLOGY AND ETHOLOGY

OBJECTIVES

- *To gain a holistic understanding of the operating factors and cycles in the environment.*
- *To understand the concepts of ecosystem, community, ecological succession and population dynamics.*
- *To understand diverse habitats and the impact of man on the environment.*
- *To study the biological rhythm, behavioural types and the play of hormones.*

UNIT - I

Environment - Abiotic factors- Atmosphere and temperature.
Limiting factors - Leibig's law and Shelford's law.
Biotic factors - Animal relationship – Interspecific, intraspecific.
Biogeochemical cycles – Oxygen, Nitrogen, Phosphorus

UNIT - II

Ecosystem – Structure and functions, food chain, food web, ecological pyramids.
Community –Definition, types, characteristics, stratification, niche, ecotone and edge effect,
Ecological succession – types, pattern, significance.
Population - Natality, mortality, density, growth, dispersal.

UNIT - III

Habitat - Fresh water (Lentic)
Marine – Stratification, Intertidal shores, deep sea.
Terrestrial – Desert.
Environmental pollution - Air, water, land, noise, radioactive pollution, e-pollution.

UNIT - IV

Behavioral patterns and pheromones.
Biological clock, circadian rhythm.
Terrestrial behaviour.
Communication - Echolocation in Bats.

UNIT - V

Motivated behaviour –Motivational pattern, Biological drives.
Courtship behaviour – Characteristics - Brood care, aggression, attention.
Learning behaviour – Types - neural mechanisms.
Ethological concepts and human behaviour - Fixed action pattern - sign stimulus - imprinting.

TEXTBOOK

- Rastogi, V.B. and Jayaraj, M.S. 1981. Animal Ecology and distribution.

REFERENCE BOOKS

1. **Eugene, P. Odum**. 1971. Fundamentals of Ecology. WB Saunders and Co. Philadelphia.
2. **Gundevia H.S, and Hare Govind Singh**, A Text book of Animal Behaviour. S. Chand & Co. New Delhi.
3. **Rehna Mathur. Kedarnath and Ramnath.** Animal Behaviour . Meerut.

III - B.Sc. ZOOLOGY

SEMESTER - VI

CORE PAPER – XII: BIOINFORMATICS, BIOSTASTISTICS & COMPUTER APPLICATIONS

OBJECTIVES

- *To introduce the basics of bioinformatics- biological databases, retrieval tools and applications.*
- *To understand data collection, data handling and data analysis.*
- *To understand computer components, certain MS Office applications, internet search engines and computer viruses.*

BIO INFORMATICS

UNIT - I

1. Definition, history, biological databases.

2. Nomenclature of DNA sequence, protein sequence.

3. Proteomics – Protein structure, PIR, entry of a SWISSPROT account.

4. Genomics – Divisions, entry of Gen Bank account.

UNIT - II

1. Data retrieval tools- Entrez, BLAST.

2. Bioinformatics in drug design.

3. Phylogeny analysis in bioinformatics.

4. Human genome project.

BIOSTATISTICS

UNIT - III

1. Data - types of data, collection of data, methods of collecting primary data, sources of secondary data.

2. Classification and tabulation of data.

3. Diagrammatic representation of data- line diagram, bar diagram (simple, component and percentage), pie diagram and pictogram.

4. Graphic representation of data – histogram, frequency polygon, frequency curve and Ogive.

UNIT - IV

1. Measures of central tendency - Arithmetic mean.

2. Measures of dispersion – Standard deviation and Standard error.

3. Student's 't' test and Chi-square test.

COMPUTER APPLICATIONS

UNIT - V

1. Components of computer.

2. MS Word, Excel, Power point.

3. Internet – Search engines (Google, Yahoo), Applications.

4. Computer virus.

REFERENCE BOOKS

- **Gupta, S.P.** 1976. Statistical methods. Sultan Chand and Sons. New Delhi.
- **Palanichamy, S. Manohar**, Statistics for Biologists, Paramount Publications, Palani.
- **Ignachimuthu S.** Basic Bioinformatics –. Narosa Publising House, New Delhi, 2005.
- **Mani, S.** Bioinformatics Vol I, II, III. Centre for Cultural Studies Pub, Coimbatore.
- **Rastogi S.C., Mendiratta, N** .Bioinformatics – Methods and Applications., Rastogi Prentice New Delhi, 2005.
- **Rajaraman. V.** Fundamentals of computers.

III – B.Sc. ZOOLOGY

SEMESTER V & VI

CORE PRACATICAL –III

(Papers covering: Paper - VIII: Evolution, Paper – XI: Ecology & Ethology and Paper – XII: Bio informatics, Biostatistics and Computer applications)

EVOLUTION

1. Homologous Organ
2. Analogous organ
3. Study of fossils – Living fossils

ECOLOGY & ETHOLOGY

1. Measurement of pH of water samples
2. Estimation of salinity of water samples
3. Estimation of dissolved oxygen in water samples
4. Study of planktons- Marine & Freshwater
5. Animals association
6. Study of fauna
    a. Intertidal rocky shore
    b. Sandy shore
    c. Muddy shore

BIOSTATISTICS

1. Collection of Biological data
2. Frequency distribution
3. Representation of data – Histogram, Frequency polygon.

BIOINFORMATICS

1. Browsing of different sites related to bioinformatics.
2. Collection of data from different sources.
3. Entry page of SWISS PROT and BLAST.

COMPUTER APPLICATIONS

1. MS – Word.
2. MS – Excel.
3. MS – Power point.

III – B.Sc. ZOOLOGY

SEMESTER – V & VI

CORE PRACTICAL – IV

(Paper Covering Paper - VI: Biochemistry and Biophysics, Paper – IX: Developmental Biology and Paper - X: Genetics)

BIO CHEMISTRY

1. Qualitative determination of Biomolecules in biological substances by the following test
    A. Determination of Protein
        (i) Molisch's test
        (ii) Iodine test
        (iii) Benedict's test
        (iv) Oxazone test

    B. Determination of Carbohydrates
        (i) Biuret test
        (ii) Ninhydrin test
        (iii) Millons test

    C. Determination of Lipids
        (i) Liberman Burchard test
        (ii) Sudan III test

BIOPHYSICS

A. Dissection microscope
B. Compound microscope
C. Binocular microscope

DEVELOPMENTAL BIOLOGY

1. Observation of prepared slides
    a. Different Developmental stages of Chick
    b. Cleavages in frog cell

2. Fetal Membranes and placenta
    a. Pig
    b. Sheep
    c. Rabbit

GENETICS

1. Study on the identification of male and female Drosophila using morphology.
2. Study of the culture of the Drosophila & identification of mutant forms.
3. Study of human Blood groups and Blood Grouping.
4. Identification of Finger prints (Whorl , Arch , Loop).

III – B.Sc. ZOOLOGY

SEMESTER – V & VI

CORE PRACTICAL - V

(Paper Covering: Paper – V: Immunology and Microbiology and Paper – VIII: Biotechnology)

IMMUNOLOGY

1. Observation of slides of Primary and Secondary Lymphoid organs

    a. Thymus
    b. Bone marrow
    c. Spleen
    d. Lymph node

2. Study of immunological tests

    a. ABO Blood typing ,Rh Blood typing
    b. WIDAL
    c. VDRL
    d. ELISA

3. Separation of Lymphocytes

MICROBIOLOGY

1. Micrometry

    a. Measurement of a cell from a prepared slide (Paramecium)
    b. Measurement of pollen grains
    c. Measurement of RBC
    d. Isolation of Microbes in the Soils - Demonstration only
    e. Isolation of Microbes from Water - Demonstration only
    f. Study of Yeast cells in Curd
    g. Study of mycelium in Bread mould
    h. Hanging drop experiment for observation of live Bacteria from any Sample

BIOTECHNOLOGY

1. Isolation of DNA from Squamous epithelial Cells of buccal region
2. Study of Ag- Ab reaction – Blood cells precipitation

3. Preparation of microbial culture media
4. Preparation of microbial slides

    a. Bacteria
    b. Algae
    c. Fungi
5. Using simple staining technique , Negative staining and differential staining
6. Immobilization of Yeast cells
7. Microbes present in spoiled Milk

VISITING LABORATORIES INVOLVED IN

a. Hybridoma Technology
b. Production of Vaccines , antibodies
c. Biogas plant
d. Commercial mushroom cultivation
e. Vermiculture.

III - B. Sc. ZOOLOGY

SEMESTER - VI

SKILL BASED SUBJECT - PAPER - IV: SERICULTURE AND APICULTURE

OBJECTIVES

- *To appreciate the scope and economics of sericulture and apiculture.*
- *To study the essentials of sericulture-silkworm rearing, mulberry cultivation, silk production.*
- *To study the essentials of apiculture- beekeeping, honey and other byproduct production.*

SERICULTURE

UNIT I

History of Sericulture.

Types of Silkworm, races of mulberry silkworm, coloured silkworms.

Silk properties and uses.

Economic importance of sericulture.

Future of Sericulture in India.

UNIT - II

Mulberry cultivation - Preparation of land, Propagation of mulberry plants, Irrigation.

Pruning and Training.

Harvesting and Storage of mulberry leaves.

Pests of mulberry plants.

Morphology and Life cycle of *Bombyx mori.*

UNIT - III

Rearing of silkworm - Rearing room, Incubation of eggs, Rearing of worms.

Rearing appliances, Feeding, Cleaning, Spacing, Mounting and Harvesting.

Silk Reeling and Appliances.

By products- Commercial value.

Diseases of silk worm - Pebrine, Flacherie, Grasserie

APICULTURE

UNIT - IV

Scope of Apiculture.

Types of Honey Bees- Life Cycle.

Bee Keeping and Bee Keeping Equipment.

Social Organization of Honey Bee.

Bee Language and Communication.

UNIT - V

Products of Apiculture -Honey-Chemical composition-Nutritional value and medicinal value.

Production of Bee wax and Uses.

Bee venom and Uses.

Bee enemies and Diseases - Nosima, Acarine, Septecaemia.

TEXT BOOK

- **Ganga, G. and Sulochana J**. An Introduction to Sericulture. 2nd edition, Oxford & IBH Publishing House Co. Pvt. Ltd., New Delhi.
- **Kumar, A. and Nigam, P. M.**, Economic and Applied Entomology.

III – YEAR

SEMESTER - VI
NON – MAJOR ELECTIVE - PAPER II – BIOFARMING –II
(For Non - Zoology students only)

UNIT- I: ORNAMENTAL FISH CULTURE

Aquarium – aims of aquarium.
Requirements in setting of an aquarium.
Aquarium fishes and their diseases.

UNIT - II: POULTRY KEEPING

Fowl breeds – Indigenous and Exotic.
Rearing of chicken- fowl house, Food and feeding of fowl.
Diseases.
Poultry products-eggs, by-products.

UNIT – III: CATTLE FARMING

Breeds of dairy animals - cow, buffalo and goat.
Rearing, food and feeding.
Diseases.
Products-milk and milk products, meat and other commercial products.

UNIT - IV: RABBIT FARMING

Breeds of dairy animals – cow, buffalo and goat.
Care and management of rabbit farms.
Products-meat, fur and wool.
Diseases

UNIT – V: ANIMAL CLONING

Transgenic animals – Definition, Mice, Fish.
Cloning – Dolly.

TEXT BOOKS

1. Economic Zoology- **G.C. Shukla and V.B. Upadhyay.**
2. Hand book of Fisheries and Aquaculture Technology**. K. R.Gupta.** Asia Pacific Business Press.
3. Aquaculture. 2008**. N. Arumugam**. Saras Publications.
4. Economic and Applied Entomology. **A. Kumar and P.M. Nigam.**
5. Commercial Broiler Production**. D. Narahari**, Madras University College, Chennai.

B.Sc. ALLIED ZOOLOGY

SEMESTER – I

PAPER – I: NON – CHORDATA AND CHORDATA

OBJECTIVES

- *To appreciate the diversity of the animal kingdom.*
- *To understand characteristics of the non-chordate phyla and the chordate classes.*
- *To study the organization and life cycle of certain economically significant organisms.*

UNIT – I

1. General characters of the Phylum Protozoa.
2. General organization and life cycle of *Plasmodium*.
3. General characters of the Phylum Porifera
4. General characters of the Phylum Coelenterata.

UNIT – II

1. General characters of the Phylum Platyhelminthes.
2. General organization and life history of *Fasciola hepatica*.
3. General characters of the Phylum Nemathelminthes.
4. Nematode parasites of man.
5. General characters of the Phylum Annelida.
6. General organization and reproduction in Earthworm.

UNIT – III

1. General characters of the phylum Arthropoda.
2. General organization and reproduction in *Periplanata americana.*
3. General characters of the Phylum Mollusca.
4. General characters of the Phylum Echinodermata.
5. General organization and reproduction in *Asterias*.

UNIT – IV

1. General characters of the Phylum chordate and outline classification up to class level.
2. General characters of the class: Pisces.
3. General organization of all systems except endoskeletal system of Shark.
4. General characters of the class: Amphibia.

UNIT – V

1. General characters of the class: Reptilia.
2. General characters of the class: Aves.
3. General characters of the class: Mammalia.
4. General organization of all systems of Rabbit except endoskeleton.

TEXT BOOKS

- **M. Ekambaranatha Ayyar & T. N. Ananthakrishnan**. Outlines of Zoology.
- **M Ekambaranatha Ayyar & T. N. Ananthakrishnan**. Manual of Zoology, Vol I & II.

REFERENCE BOOKS

1. **R. L. Kotpal**. Modern textbook of Zoology: Invertebrates.
2. **R. L. Kotpal**. Modern textbook of Zoology: Vertebrates.

B. Sc. ALLIED ZOOLOGY

SEMESTER – II

PAPER – II: GENERAL PRINCIPLES OF ZOOLOGY

OBJECTIVES

- *To understand the scope and branches of zoology.*
- *To introduce certain aspects of genetics, cell biology, developmental biology, ethology and economic zoology.*

UNIT – I – GENETICS & CELL BIOLOGY

1. Genetic disorders in Man – Haemophilia, Phenylketonuria and Down's syndrome.
2. Blood groups – A, B, O and Rh.
3. Eugenics, Euthenics and Genetic counselling.
4. An account of Cancer.

UNIT – II – DEVELOPMENTAL BIOLOGY

1. Structure of egg and sperm of Rabbit.
2. Fertilization, Cleavage, Blastulation and Gastrulation in Rabbit.
3. Fetal membranes (yolk, sac, amnion, chorion and allantois) and Placenta in Rabbit.
4. Human infertility and *in vitro* fertilization.

UNIT – III – PHYSIOLOGY

1. Respiration – Hb and Gaseous transport.
2. Excretion – Nephron – structure and urine formation.
3. Structure of Neuron – Nerve impulse conduction – synaptic transmission.

UNIT – IV – BEHAVIOUR AND ADAPTATIONS

1. Parental care.
2. Migration in Birds.
3. Natatorial adaptations.
4. Volant adaptations.
5. Desert adaptations.
6. Cave adaptations.

UNIT – V – ECONOMIC ZOOLOGY

1. Life cycle of silk worm – Economic importance of silk.
2. Life cycle of Honey bee – Economic importance of honey.
3. Fish culture – Economic importance of fish.

TEXT BOOK

- A Text Book of Embryology – **N. Arumugam.**

REFERENCES

- **P.S. Verma & Agarwal**. 2001. Concepts of Cell Biology. S. Chand & Co.

B.Sc. ALLIED ZOOLOGY PRACTICALS

SEMESTER - I & II

(Papers covering: Non – Chordata, Chordata and General Principles of Zoology)

DISSECTIONS

1. Fish – Alimentary canal.
2. Cockroach – Alimentary canal.

MOUNTINGS

1. Cockroach – Mouth parts.
2. Honey bee - Mouth parts.
3. Types of scales in Fish.

SPOTTERS – IDENTIFICATION

Identify, draw and write notes:

1. *Paramecium*: Entire.
2. Ascon: Entire.
3. *Obelia*: Colony, Medusa.
4. *Fasciola hepatica*: Entire.
5. *Ascaris*: Entire.
6. *Penaeus*: Entire.
7. Pila: Entire.
8. Starfish: Entire – Oral and Aboral view.
9. Shark: Entire.
10. Frog: Entire.
11. *Calotes*: Entire.
12. Pigeon: Entire.
13. Rat: Entire.

EMBRYOLOGY

1. Structure of egg and sperm of frog.
2. Blastula of Frog.
3. Gastrula of Frog.
4. Placenta of Mammals – Rabbit.

ADAPTATIONAL SIGNIFICANCE

1. Natatorial – Turtle.
2. Volant – Draco and Bat.

ANIMAL BEHAVIOUR

1. Parental care – Arius, Alytes.

ECONOMIC ZOOLOGY

1. Honey bee – Different castes.
2. Silkworm – Adult, Caterpillar, Pupa and Cocoon.
3. Pisciculture – Edible fishes.