

**SYLLABUS UNDER CHOICE BASED CREDIT SYSTEM**  
**B.Sc. HONOURS WITH ZOOLOGY**

Semester	CORE COURSE (14)	Ability Enhancement Compulsory Courses AEC (2)	Skill Enhancement Courses SEC (2)	Discipline Specific Elective DSE (4)	Generic Elective GE (4)
I	Non-chordates I: Protista to Pseudocoelomates	English Communication			GE-1
	Principles of Ecology				
II	Non-chordates II: Coelomates	Environmental Science			GE-2
	Cell Biology				
III	Diversity of Chordates		SEC-1		GE-3
	Physiology: Controlling and Coordinating Systems				
	Fundamentals of Biochemistry				
IV	Comparative Anatomy of Vertebrates		SEC-2		GE-4
	Physiology: Life Sustaining Systems				
	Biochemistry of Metabolic Processes				
V	Molecular Biology			DSE-1	
	Principles of Genetics			DSE-2	
VI	Developmental Biology			DSE-3	
	Evolutionary Biology			DSE-4	

**Discipline Core Courses (CC):**

- CC-I : Non-chordates I: Protista to Pseudocoelomates + Practical  
 CC-II : Principles of Ecology + Practical  
 CC-III : Non-chordates II: Coelomates + Practical  
 CC-IV : Cell Biology + Practical  
 CC-V : Diversity of chordates + Practical  
 CC-VI : Physiology: Controlling and Coordinating systems + Practical  
 CC-VII : Fundamentals of Biochemistry + Practical  
 CC-VIII : Comparative anatomy of vertebrates + Practical  
 CC-IX : Physiology: Life Sustaining Systems + Practical  
 CC-X : Biochemistry of Metabolic Processes + Practical

- CC-XI : Molecular Biology + Practical  
CC-XII : Principles of Genetics + Practical  
CC-XIII : Developmental Biology + Practical  
CC-IV : Evolutionary Biology + Practical

**Ability Enhancement Compulsory Course (AEC):**

English Communications

Environmental Science

**Skill Enhancement Course (SEC):**

**SEC 1**

- a) Apiculture
- b) Research Methodology

**SEC 2**

- a) Aquarium Fish Keeping
- b) Medical Diagnostics

**DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE):**

**DSE – 1**

- (a): Animal Behaviour and Chronobiology + Practical
- (b): Animal Biotechnology + Practical
- (c): Basics of Neuroscience + Practical

**DSE – 2**

- (a): Biology of Insecta + Practical
- (b): Computational Biology + Practical
- (c): Endocrinology + Practical

**DSE – 3**

- (a): Fish and Fisheries + Practical
- (b): Immunology + Practical
- (c): Parasitology + Practical

**DSE – 4**

- (a): Reproductive Biology + Practical
- (b): Wild Life Conservation and Management + Practical
- (c): Computational Biology + Practical

**GENERIC ELECTIVE COURSES (GE):**

**GE 1**

- (a) Animal Cell Biotechnology + Practical
- (b) Animal Diversity + Practical

**GE 2**

- (a) Aquatic Biology + Practical
- (b) Environment and Public Health + Practical

**GE 3**

- (a) Exploring the Brain: Structure and Function + Practical
- (b) Food, Nutrition and Health + Practical

**GE 4**

- (a) Human Physiology + Practical
- (b) Insect Vectors and Diseases + Practical

## CORE COURSE I

### NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

#### THEORY

(Credits 4)

##### Unit 1:

General characteristics and Classification up to classes

Study of *Euglena*, *Amoeba* and *Paramecium*

Life cycle and pathogenicity of *Plasmodium vivax* and *Entamoeba histolytica*

Locomotion and Reproduction in Protista

##### Unit 2:

Evolution of symmetry and segmentation of Metazoa

General characteristics of Porifera and Classification up to classes

Canal system and Spicules in Sponges

##### Unit 3:

General characteristics of Cnidaria and Classification up to classes

Metagenesis in Obelia

Polymorphism in Cnidaria

Corals and coral reefs

##### Unit 4:

General characteristics of Ctenophora and Evolutionary significance

General characteristics of Platyhelminthes and classification up to classes

Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*

##### Unit 5:

General characteristics of Nematelminthes and Classification up to classes

Life cycle and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*

Parasitic adaptations in Helminthes

**Note:** Classification to be followed from “Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition”

## NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

### PRACTICALS

(Credits 2)

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium*
2. Examination of pond water collected from different places for diversity in Protista
3. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongilla*
4. Study of *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora*
5. One specimen/slide of any Ctenophore
6. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/microphotographs)
7. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
8. Identification and taxonomic classification of representative invertebrates

**Note:** Classification to be followed from “Ruppert and Barnes (2006) *Invertebrate Zoology*, 8th edition, Holt Saunders International Edition”

### SUGGESTED READINGS

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
- Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson

**CORE COURSE II**  
**PRINCIPLES OF ECOLOGY**

**THEORY**

**(Credits 4)**

**Unit 1:**

History of Ecology, Autecology and Synecology,  
Levels of organization, Laws of limiting factors, Study of physical factors  
Ecology in Wildlife Conservation and Management

**Unit 2:**

Unitary and Modular populations  
Unique and group attributes of population: density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion  
Exponential and logistic growth, equation and patterns, r and k strategies

**Unit 3:**

Population regulation - density-dependent and independent factors  
Population interactions, Gause's Principle with laboratory and field examples,  
Lotka-Volterra equation for competition and predation, functional and numerical responses

**Unit 4:**

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, ecotone and edge effect; ecological succession with one example.  
Theories pertaining to climax community

**Unit 5:**

Types of ecosystems with one example in detail; food chain: detritus and grazing food chains, Linear and Y-shaped food chains, food web, energy flow through the ecosystem, ecological pyramids and ecological efficiencies  
Nutrient and biogeochemical cycle with one example of nitrogen cycle  
Human modified ecosystem

## **PRINCIPLES OF ECOLOGY**

### **PRACTICALS**

**(Credits 2)**

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: phytoplankton and zooplankton; measurement of area, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), chemical oxygen demand and free CO<sub>2</sub>
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

### **SUGGESTED READINGS**

- Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Robert Leo Smith Ecology and field biology Harper and Row publisher
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Pres

**CORE COURSE III**  
**NON-CHORDATES II: COELOMATES**

**THEORY**

**(Credits 4)**

**Unit 1:**

Evolution and significance of coelom and metamerism  
General characteristics and evolutionary significance of Onychophora

**Unit 2:**

General characteristics of Annelida and Classification up to classes  
Excretion, locomotion and economic importance of Annelida

**Unit 3:**

General characteristics of Arthropoda and Classification up to classes  
Vision and Respiration in Arthropoda  
Metamorphosis and parthenogenesis in insects

**Unit 4:**

General characteristics of Mollusca and Classification up to classes  
Respiration in Mollusca  
Torsion and detorsion in Gastropoda  
Pearl formation in bivalves  
Evolutionary significance of trochophore larva

**Unit 5:**

General characteristics of Echinodermata and Classification up to classes  
Water-vascular system in Asterozoa  
Larval forms in Echinodermata  
Affinities with Chordates

**Note:** *Classification to be followed from “Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition”*

## NON-CHORDATES II: COELOMATES

### PRACTICAL

(Credits 2)

1. Study of following specimens:

Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*

Arthropods - *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta*, termites and honey bees

Onychophora - *Peripatus*

Molluscs - *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*

Echinodermates - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*

2. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm

3. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm

4. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta*\*

5. To submit a Project Report on any related topic to larval forms (crustacean, mollusc and echinoderm)

**Note:** Classification to be followed from “Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition”

### SUGGESTED READINGS

- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition
- Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson

## **CORE COURSE IV**

### **CELL BIOLOGY**

#### **THEORY**

**(Credits 4)**

##### **Unit 1:**

Prokaryotic and Eukaryotic cells; virus, viroids, mycoplasma, prions

Various models of plasma membrane structure

Transport across membranes: active and passive transport, facilitated transport

Cell junctions: tight junctions, desmosomes, gap junctions

##### **Unit 2:**

Structure and Functions: endoplasmic reticulum, Golgi apparatus, lysosomes

Transport systems involving endoplasmic reticulum, Golgi apparatus, lysosomes

##### **Unit 3:**

Mitochondria: Structure; semi-autonomous nature; endosymbiotic hypothesis; mitochondrial respiratory chain; chemi-osmotic hypothesis

Peroxisomes

##### **Unit 4:**

Structure of Nucleus: nuclear envelope, nuclear pore complex, nucleolus,

Chromatin: euchromatin and heterochromatin and packaging (nucleosome)

##### **Unit 5:**

Mitosis, meiosis, cell cycle and its regulation

Structure and Functions: microtubules, microfilaments and intermediate filaments

## CELL BIOLOGY

### PRACTICAL

(Credits 2)

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of various stages of meiosis.
3. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
4. Preparation of permanent slide to demonstrate:
  - a) DNA by Feulgen reaction
  - b) DNA and RNA by MGP
  - c) Mucopolysaccharides by PAS reaction
  - d) Proteins by Mercurobromophenol blue/Fast Green

### SUGGESTED READINGS

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia
- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

**CORE COURSE V**  
**DIVERSITY OF CHORDATA**

**THEORY**

**(Credits 4)**

**Unit 1:**

General characteristics of chordates and outline classification  
General characteristics of Hemichordata, Urochordata and Cephalochordata;  
Study of larval forms in protochordates;  
Retrogressive metamorphosis in Urochordata

**Unit 2:**

Dipleurula concept and the Echinoderm theory of origin of chordates; Advanced features of vertebrates over Protochordata  
General characteristics of Agnatha and classification of Cyclostomes up to class

**Unit 3:**

General characteristics of Chondrichthyes and Osteichthyes, classification up to order  
Migration, Osmoregulation and Parental care in fishes  
General characteristics of Amphibia and classification up to order;  
Origin of *Tetrapoda* (Evolution of terrestrial ectotherms);  
Parental care in Amphibians

**Unit 4:**

General characteristics of Reptilia and classification up to order;  
Affinities of *Sphenodon*;  
Poison apparatus and Biting mechanism in snakes  
General characteristics and classification up to order *Archaeopteryx* - a connecting link;  
Principles and aerodynamics of flight; Flight adaptations and Migration in birds

**Unit 5:**

General characters of mammals and classification up to order; Affinities of Prototheria;  
Adaptive radiation with reference to locomotory appendages;  
Zoogeographical realms,

## DIVERSITY OF CHORDATA

### PRACTICAL

(Credits 2)

1. **Protochordata:** *Balanoglossus*, *Herdmania*, *Branchiostoma*, Colonial Urochordata Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules
2. **Agnatha:** *Petromyzon*, *Myxine*
3. **Fishes:** *Scoliodon*, *Sphyrna*, *Pristis*, *Torpedo*, *Chimaera*, *Mystus*, *Heteropneustes*, *Labeo*, *Exocoetus*, *Echeneis*, *Anguilla*, *Hippocampus*, *Tetrodon/ Diodon*, *Anabas*, Flat fish
4. **Amphibia:** *Ichthyophis/Ureotyphlus*, *Necturus*, *Bufo*, *Hyla*, *Alytes*, *Salamandra*
5. **Reptilia:** *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Ophiosaurus*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis*, *Crocodylus*  
Key for Identification of poisonous and non-poisonous snakes
6. **Aves:** Study of six common birds from different orders. Types of beaks and claws
7. **Mammalia:** *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceous*. Mount of weberian ossicles of *Mystus*, pecten from Fowl head

Dissection of Fowl head (Dissections and mounts subject to permission)

Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission)

*Classification from Young, J. Z. (2004) to be followed*

### SUGGESTED READINGS

- Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
- Pough H. Vertebrate life, VIII Edition, Pearson International.
- Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub Co.
- Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

## **CORE COURSE VI**

### **ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS**

**OR**

### **ANIMAL PHYSIOLOGY I**

#### **THEORY**

**(Credits 4)**

#### **Unit 1:**

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue

Structure and types of bones and cartilages, ossification, bone growth and resorption

#### **Unit 2:**

Structure of neuron, resting membrane potential; origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; types of synapse, synaptic transmission and, neuromuscular junction; reflex action and its types - reflex arc; physiology of hearing and vision.

#### **Unit 3:**

Histology of different types of muscle; Ultra structure of skeletal muscle; molecular and chemical basis of muscle contraction; characteristics of muscle twitch; motor unit, summation and tetanus

#### **Unit 4:**

Structure of testis and ovary; physiology of male and female reproduction;

Spermatogenesis and oogenesis

Hormones of reproduction

#### **Unit 5:**

Endocrine glands in vertebrates; structures of cells and types;

Classification of hormones; mode of hormone action; signal transduction pathways for steroidal and non-steroidal hormones; hypothalamus and pituitary – their structures and functions.

## **ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS**

### **PRACTICALS**

**(Credits 2)**

- \*1. Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: squamous epithelium, striated muscle fibres and nerve cells
4. Study of permanent slides of mammalian skin, cartilage, bone, spinal cord, nerve cell, pituitary, pancreas, testis, ovary, adrenal, thyroid and parathyroid
5. Microtomy: preparation of permanent slide of any five mammalian (goat/white rat) tissues

**(\*Subject to UGC guidelines)**

### **SUGGESTED BOOKS**

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.

**CORE COURSE VII**  
**FUNDAMENTALS OF BIOCHEMISTRY**

**THEORY**

**(CREDITS 4)**

**Unit 1:**

Carbohydrate structure and classification; monosaccharides, disaccharides, polysaccharides; carbohydrate metabolism – glycolysis and gluconeogenesis.

**Unit 2:**

Lipid classification; tri-acylglycerols, phospholipids, glycolipids, cholesterol and steroids – their functions.

**Unit 3:**

Proteins and Amino acids: structure, classification and general properties of  $\alpha$ -amino acids; physiological importance of essential and non-essential  $\alpha$ -amino acids; bonds stabilizing protein structure; levels of organization in proteins; primary, secondary, tertiary and quaternary structures.

**Unit 4:**

Nucleic Acids: structure of purines and pyrimidines, nucleosides, nucleotides, nucleic acids  
Cot Curves: base pairing, denaturation and renaturation of DNA; types of DNA and RNA; complementarity of DNA, hyperchromaticity of DNA

**Unit 5:**

Enzyme nomenclature and classification; cofactors; specificity of enzyme action; isozymes; mechanism of enzyme action; enzyme kinetics; factors affecting rate of enzyme-catalyzed reactions; derivation of Michaelis-Menten equation; concept of  $K_m$  and  $V_{max}$ ; Lineweaver-Burk plot;

## FUNDAMENTALS OF BIOCHEMISTRY

### PRACTICAL

(CREDITS 2)

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase.
5. Demonstration of proteins separation by SDS-PAGE.

### SUGGESTED READING

- Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

**CORE COURSE VIII**  
**COMPARATIVE ANATOMY OF VERTEBRATES**

**THEORY**

**(CREDITS 4)**

**Unit 1:**

Integumentary System: structure, functions and derivatives of integument

Respiratory System: skin, gills, lungs and air sacs; Accessory respiratory organs

**Unit 2:**

Skeletal System: overview of axial and appendicular skeleton, jaw suspensorium, visceral arches

**Unit 3:**

Digestive System: alimentary canal and associated glands, dentition

**Unit 4:**

Circulatory System: general plan of circulation, evolution of heart and aortic arches;

Urinogenital System: succession of kidney; evolution of urinogenital ducts; types of mammalian uteri

**Unit 5:**

Nervous System: comparative account of brain, autonomic nervous system, spinal cord, cranial nerves in mammals

Sense Organs: classification of receptors; brief account of visual and auditory receptors in man

## **COMPARATIVE ANATOMY OF VERTEBRATES**

### **PRACTICAL**

**(CREDITS 2)**

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, Varanus, Fowl, Rabbit
3. Carapace and plastron of turtle /tortoise
4. Mammalian skulls: one herbivorous and one carnivorous animal
5. Dissection of rat to study arterial and urinogenital system (subject to permission)
6. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted)
7. Project on skeletal modifications in vertebrates (may be included if dissection not permitted)

### **SUGGESTED READINGS**

- Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education
- Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
- Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons
- Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House

## **CORE COURSE IX**

### **ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS**

#### **THEORY**

**(Credits 4)**

##### **Unit 1:**

Structural organization and functions of gastrointestinal tract and associated glands; Digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Enzymes in Gastrointestinal tract.

##### **Unit 2:**

Mechanism of respiration, pulmonary ventilation; transport of oxygen and carbon dioxide in blood; respiratory pigments, dissociation curves and oxyhaemoglobin.

##### **Unit 3:**

Structure of kidney and nephron; mechanism of urine formation and osmoregulation; Regulation of water balance;

##### **Unit 4:**

Ag–Ab reactions; structure and classification of Igs; haemostasis: blood clotting system, Blood groups: Rh factor, ABO and antigenic determinants.

##### **Unit 5:**

Structure of mammalian heart; coronary circulation; origin and conduction of cardiac impulses; cardiac cycle; electrocardiogram; blood pressure and its regulation; composition of blood and its functions.

## ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS

### PRACTICALS

(CREDITS 2)

1. Determination of ABO Blood group
2. Enumeration of red blood cells and white blood cells using haemocytometer
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals
5. Recording of frog's heart beat under *in situ* and perfused conditions\*
6. Recording of blood pressure using a sphygmomanometer
7. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney

(\*Subject to UGC guidelines)

### SUGGESTED READINGS

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hecourt Asia PTE Ltd. W.B. Saunders Company.
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

## CORE COURSE X

### BIOCHEMISTRY OF METABOLIC PROCESSES

#### THEORY

(CREDITS 4)

##### Unit 1:

Catabolism vs anabolism, stages of catabolism; compartmentalization of metabolic pathways, shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; use of reducing equivalents and cofactors; intermediary metabolism and regulatory mechanisms

##### Unit 2:

Sequence of reactions and regulation of glycolysis, citric acid cycle, phosphate pentose pathway, gluconeogenesis, glycogenolysis and glycogenesis

##### Unit 3:

$\beta$ -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; biosynthesis of palmitic acid; ketogenesis

##### Unit 4:

Catabolism of amino acids: transamination, deamination, urea cycle;  
Fate of C-skeleton of glucogenic and ketogenic amino acids

##### Unit 5:

Redox systems; review of mitochondrial respiratory chain;  
Inhibitors and un-couplers of Electron Transport System

## BIOCHEMISTRY OF METABOLIC PROCESS

### PRACTICALS

(CREDITS 2)

1. Estimation of total protein in given solutions by Lowry's method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
3. To study the enzymatic activity of trypsin and lipase.
4. Study of biological oxidation (SDH) [goat liver]
5. To perform the Acid and alkaline phosphatase assay from serum/ tissue.
6. Dry Lab: to trace the labelled C atoms of acetyl-CoA till they evolve as CO<sub>2</sub> in the TCA cycle

### SUGGESTED READINGS

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

**CORE COURSE XI**  
**MOLECULAR BIOLOGY**

**THEORY**

**(CREDITS 4)**

**Unit 1:**

DNA as genetic material; Watson and Crick model of DNA

DNA replication in prokaryotes and eukaryotes; mechanism of DNA replication; semi-conservative, bidirectional and semi-discontinuous replication; RNA priming; replication of circular and linear ds-DNA; replication of telomeres

**Unit 2:**

RNA polymerase and transcription Unit; mechanism of transcription in prokaryotes and eukaryotes; synthesis of rRNA and mRNA; transcription factors

**Unit 3:**

Genetic code; degeneracy of the genetic code and Wobble Hypothesis; process of protein synthesis in prokaryotes; inhibitors of protein synthesis; difference between prokaryotic and eukaryotic translation

**Unit 4:**

Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing; processing of tRNA; pyrimidine dimerization and mismatch repair

**Unit 5:**

Transcription regulation in prokaryotes: principles of transcriptional regulation with examples from lac operon and trp operon; transcription regulation in eukaryotes: activators, repressors, enhancers, silencer elements; gene silencing, genetic imprinting

## MOLECULAR BIOLOGY

### PRACTICAL

REDITS 2)

1. Study of polytene chromosomes from *Chironomous / Drosophila* larvae
2. Preparation of liquid culture medium (LB) and raise culture of *E. coli*
3. Estimation of the growth kinetics of *E. coli* by turbidity method
4. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking
5. Demonstration of antibiotic sensitivity/resistance of *E. coli* to antibiotic pressure and interpretation of results
6. Quantitative estimation of salmon sperm/calf thymus DNA using colorimeter (diphenylamine reagent) or spectrophotometer (A260 measurement)
7. Quantitative estimation of RNA using Orcinol reaction
8. Study and interpretation of electron micrographs/ photograph showing
  - (a) DNA replication
  - (b) Transcription
  - (c) Split genes

### SUGGESTED READINGS

- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: Molecular Biology of the Cell, IV Edition.
- Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
- Lewin B. (2008). Gene XI, Jones and Bartlett
- McLennan A., Bates A., Turner, P. and White M. (2015). Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.

**CORE COURSE XII**  
**PRINCIPLES OF GENETICS**

**THEORY**

**(CREDITS 4)**

**Unit 1:**

Principles of inheritance; incomplete dominance and co-dominance; multiple alleles, lethal alleles, epistasis, pleiotropy, sex-linked, sex-influenced and sex-limited characters inheritance.

**Unit 2:**

Linkage and crossing over; cytological basis of crossing over; molecular mechanisms of crossing over; recombination frequency as a measure of linkage intensity; two factor and three factor crosses; interference and coincidence; somatic cell hybridization.

**Unit 3:**

Types of gene mutations (classification); types of chromosomal aberrations (classification, figures and with one suitable example of each); molecular basis of mutations in relation to UV light and chemical mutagens; detection of mutations: CLB method, attached X method.

**Unit 4:**

Sex chromosomes and sex determination; mechanisms of sex determination in *Drosophila*, Sex-linked chromosomal abnormalities; polygenic inheritance; criteria for extra-chromosomal inheritance; mitochondrial mutations in *Saccharomyces*.

**Unit 5:**

Conjugation, transformation, transduction; bacteria and bacteriophage; transposable elements; transposons in bacteria; P elements in *Drosophila*.

## PRINCIPLES OF GENETICS

### PRACTICALS

(CREDITS 2)

1. To study the Mendelian laws and gene interactions.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from conjugation, transformation and transduction.
4. Linkage maps based on data from *Drosophila* crosses.
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.

### SUGGESTED READINGS

- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings
- Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings
- Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co
- Fletcher H. and Hickey I. (2015). Genetics. IV Edition. GS, Taylor and Francis Group, New York and London.

**CORE COURSE XIII**  
**DEVELOPMENTAL BIOLOGY**

**THEORY**

**(CREDITS 2)**

**Unit 1:**

Historical perspective and basic concepts: phases of development, cell-cell interaction, Pattern formation, differentiation and growth, cytoplasmic determinants and asymmetric cell division

**Unit 2:**

Gametogenesis, spermatogenesis, oogenesis; types of eggs, egg membranes; fertilization (External and Internal): changes in gametes, blocks to polyspermy; planes and patterns of cleavage; fate maps (including Techniques); early development of frog and chick up to gastrulation; embryonic induction and organizers

**Unit 3:**

Fate of germ layers; extra-embryonic membranes in birds; implantation of embryo in humans, placenta (structure, types and functions of placenta)

**Unit 4:**

Metamorphosis: changes, hormonal regulations in amphibians and insects; regeneration: modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); ageing: concepts and theories

**Unit 5:**

Teratogenesis: teratogenic agents and their effects on embryonic development; *In vitro* fertilization, stem cell (ESC), amniocentesis

## DEVELOPMENTAL BIOLOGY

### PRACTICALS

(CREDITS 2)

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

### SUGGESTED READINGS

- Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
- Carlson, R. F. Patten's Foundations of Embryology
- Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
- Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press

**CORE COURSE XIV**  
**EVOLUTIONARY BIOLOGY**

**THEORY**

**(CREDITS 4)**

**Unit 1:**

Origin of life; historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism

**Unit 2:**

Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Molecular universality of genetic code and protein synthesising machinery; three domains of life, neutral theory of molecular evolution, molecular clock, example of globin gene family, rRNA/cyt c; heritable variations and their role in evolution

**Unit 3:**

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); evolutionary forces upsetting H-W equilibrium; natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. genetic drift (mechanism, founder's effect, bottleneck phenomenon; role of migration and mutation in changing allele frequencies

**Unit 4:**

Product of evolution: micro evolutionary changes (inter-population variations, clines, races, Species concept, isolating mechanisms, modes of speciation—allopatric, sympatric, adaptive radiation / macroevolution (exemplified by Galapagos finches)

**Unit 5:**

Origin and evolution of man; unique hominin characteristics contrasted with primate characteristics; primate phylogeny from *Dryopithecus* leading to *Homo sapiens*; molecular analysis of human origin

Phylogenetic trees, multiple sequence alignment, construction of phylogenetic trees, interpretation of trees

## **EVOLUTIONARY BIOLOGY**

### **PRACTICALS**

**(CREDITS 2)**

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.
6. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.

### **SUGGESTED READINGS**

- Ridley, M (2004) Evolution III Edition Blackwell publishing
- Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
- Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
- Snustad. S Principles of Genetics.
- Pevsner, J (2009). Bioinformatics and Functional Genomics. II Edition Wiley-Blackwell

## **DISCIPLINE CENTRIC ELECTIVE COURSES**

### **DSE 1(a)**

#### **ANIMAL BEHAVIOUR AND CHRONOBIOLOGY**

##### **THEORY**

**(Credits 4)**

##### **Unit 1:**

Origin and history of ethology; brief profiles of Karl Von Frish, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Proximate and ultimate causes of behaviour, Methods and recording of a behaviour

##### **Unit 2:**

Stereotyped behaviours (Orientation, Reflexes); individual behavioural patterns; instinct vs. learnt behaviour; associative learning, classical and operant conditioning, habituation, imprinting.

##### **Unit 3:**

Social Behaviour: concept of society; communication and the senses; altruism; insects' society with honey bee as example; foraging in honey bee and advantages of the waggle dance.

Sexual Behaviour: asymmetry of sex, sexual dimorphism, mate choice, intra-sexual selection (male rivalry), inter-sexual selection (female choice), sexual conflict in parental care.

##### **Unit 4:**

Historical developments in chronobiology; biological oscillation: the concept of Average, amplitude, phase and period; adaptive significance of biological clocks

##### **Unit 5:**

Types and characteristics of biological rhythms: short- and long- term rhythms; circadian rhythms; tidal rhythms and lunar rhythms; concept of synchronization and masking; photic and non-photoc zeitgebers; circannual rhythms; photoperiod and regulation; seasonal reproduction of vertebrates; role of melatonin.

Relevance of biological clocks; chronopharmacology, chronomedicine, chronotherapy.

## **ANIMAL BEHAVIOUR AND CHRONOBIOLOGY**

### **PRACTICAL**

**(Credits 2)**

1. To study nests and nesting habits of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm.
4. To study the phototaxis behaviour in insect larvae.
5. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.
6. Study and actogram construction of locomotor activity of suitable animal models.
7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

### **SUGGESTED READINGS**

- David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.
- Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge, University Press, UK.
- John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.
- Paul W. Sherman and John Alcock, Exploring Animal Behaviour, Sinauer Associate Inc., Massachusetts, USA.
- Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
- Insect Clocks D.S. Saunders, C.G.H. Steel, X., Afopoulou (ed.)R.D. Lewis. (3rdEd) 2002 Barends and Noble Inc. New York, USA
- Biological Rhythms: Vinod Kumar (2002) Narosa Publishing House, Delhi/ Springer-Verlag, Germany.

## DSE 1(b)

### ANIMAL BIOTECHNOLOGY

#### **THEORY**

**(Credits 4)**

##### **Unit 1:**

Concept and scope of biotechnology

##### **Unit 2:**

Cloning vectors: plasmids, cosmids, phagemids, lambda bacteriophage, M13, BAC, YAC, MAC and expression vectors (characteristics).

Restriction enzymes: nomenclature, detailed study of Type II.

Transformation techniques: Calcium chloride method and electroporation.

##### **Unit 3:**

Construction of genomic and cDNA libraries and screening by colony and plaque hybridization; Southern, Northern and Western blotting

DNA sequencing: Sanger method; Polymerase Chain Reaction; DNA Finger Printing and DNA micro array

##### **Unit 4:**

Production of cloned and transgenic animals: nuclear transplantation; retroviral method, DNA microinjection

Applications of transgenic animals: production of pharmaceuticals, production of donor organs, knockout mice.

Production of transgenic plants: Agrobacterium mediated transformation.

Applications of transgenic plants: insect and herbicide resistant plants.

##### **Unit 5:**

Animal cell culture, expressing cloned genes in mammalian cells, molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia)

Recombinant DNA in medicines: recombinant insulin and human growth hormone; gene therapy

## ANIMAL BIOTECHNOLOGY

### PRACTICAL

(Credits 2)

1. Genomic DNA isolation from *E. coli*
2. Plasmid DNA isolation (pUC 18/19) from *E. coli*
3. Restriction digestion of plasmid DNA.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques through photographs
  - a. Southern Blotting
  - b. Northern Blotting
  - c. Western Blotting
  - d. DNA Sequencing (Sanger's Method)
  - e. PCR
  - f. DNA fingerprinting
7. Project report on animal cell culture

### SUGGESTED READINGS

- Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
- Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA
- Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. V Edition, John Wiley and Sons Inc.
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y.,USA.
- Beauchamp, T.I. and Childress, J.F. (2008). Principles of Biomedical Ethics. VI Edition, Oxford University Press.

## DSE 1(c)

### BASICS OF NEUROSCIENCE

#### THEORY

(Credits 4)

##### Unit 1:

Origins of Neuroscience; neuroanatomy, neurophysiology, and systems neurobiology

##### UNIT 2:

Introduction to the structure and function of the nervous system;

Cellular components: neurons; neuroglia; neuron doctrine; prototypical neuron – axons and dendrites as unique structural components of neurons.

Ionic bases of resting membrane potential; the action potential- its generation and properties; action potential conduction.

##### UNIT 3:

Molecular and cellular approaches used to study the CNS at the level of single molecules, Synapse: synaptic transmission, types of synapses; synaptic function; principles of chemical synaptic transmission; principles of synaptic integration; EPSPs and IPSPs, ion channels, neural transmission,

##### Unit 4:

Different types of neurotransmitters – catecholamines, amino acidergic and peptidergic neurotransmitters; transmitter gated channels; G-protein coupled receptors and effectors, neurotransmitter receptors; ionotropic and metabotropic receptors; dopamine.

##### Unit 5:

The principles of signal transduction and information processing in the vertebrate central nervous system, and the relationship of functional properties of neural systems with perception and behavior; sensory systems, molecular basis of behavior including learning and memory.

Molecular pathogenesis of pain and neurodegenerative diseases such as Parkinson's, Alzheimer's, psychological disorders, addiction, *etc.*

## **BASICS OF NEUROSCIENCE**

### **PRACTICAL**

**(CREDITS 2)**

1. Dissection and study of *Drosophila* nervous system using GFP reporter.
2. Observation and quantitation of *Drosophila* photoreceptor neurons in healthy and diseased condition.
3. Nerve Cell preparation from the spinal cord.
4. Study of neurons and/ or myelin by Nissl, Giemsa or Luxol Fast Blue staining.
5. Study of olfaction in *Drosophila*.
6. Study of novelty, anxiety and spatial learning in mice.

### **SUGGESTED READINGS**

- Neuroscience: Exploring the brain by Mark F. Baer; Barry W. Connors. 2015
- From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience by John H. Byrne. Ruth Heidelberg and M. Neal Waxham
- Neuroscience-Eds. Dale Purves et. al. (3rd Edn)-Sinauer Associates, Inc.-2004
- Principles of Neural Science-4th Edn-Eds. Kandel, Schwartz and Jessell- McGrawHill Companies-2000
- Nerve Cells and Animal Behaviour-2nd Edn-Peter J Simmons and David YoungCUP-2003
- Essential Psychopharmacology- Neuroscientific Basis and Practical Applications2nd Edn.-Stephan M. Stahl-CUP-2000
- Phantoms in the Brain - Vilayanur S. Ramachandran and Sandra Blakeslee-1998
- The Human Brain Book - Rita Carter-2009

## DSE 2(a)

### BIOLOGY OF INSECTA

#### **THEORY**

**(Credits 4)**

##### **Unit I:**

General Features of Insects

Distribution and Success of Insects on the Earth

Basis of insect classification; classification of insects up to orders

##### **Unit II:**

External Features; head – eyes, types of antennae, mouth parts w.r.t. feeding habits

Thorax: wings and wing articulation; types of legs adapted to diverse habitat

Abdominal appendages and genitalia

##### **Unit III:**

Structure and physiology of insect body systems - integumentary, digestive, excretory, circulatory, respiratory, endocrine, reproductive, and nervous system

Sensory receptors

Growth and metamorphosis

##### **Unit IV:**

Social insects and their social life

Social organization and social behaviour (w.r.t. any one example)

Theory of co-evolution, role of allelochemicals in host plant mediation

Host-plant selection by phytophagous insects; insects as plant pests

##### **Unit V:**

Insects as mechanical and biological vectors,

Brief discussion on houseflies and mosquitoes as important insect vectors

## BIOLOGY OF INSECTA

### PRACTICAL

(CREDITS 2)

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

**Field study of insects and submission of a project report on the insect diversity**

### SUGGESTED READINGS

- A general text book of entomology, Imms , A. D., Chapman & Hall, UK
- The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK
- Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
- Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M Saunders College Publication, USA
- The Insect Societies, Wilson, E. O., Harward Univ. Press, UK
- Host Selection by Phytophagous insects, Bernays, E. A., and Chapman, R. F., Chapman and Hall, New York, USA
- Physiological system in Insects, Klowden, M. J., Academic Press, USA
- The Insects, An outline of Entomology, Gullan, P. J. , and Cranston, P. S., Wiley Blackwell, UK
- Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA

## DSE 2(b)

### COMPUTATIONAL BIOLOGY

#### THEORY

(Credits 4)

##### Unit 1:

Importance, goal, scope; genomics, transcriptomics, systems biology, functional genomics, metabolomics, molecular phylogeny; applications and limitations of bioinformatics

##### Unit 2:

Introduction to biological databases; primary, secondary and composite databases; nucleic acid databases (GenBank, DDBJ, EMBL and NDB); protein databases (PIR, SWISS-PROT, TrEMBL, PDB); metabolic pathway database (KEGG, EcoCyc, and MetaCyc); small molecule databases (PubChem, Drug Bank, ZINC, CSD)

##### Unit 3:

Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez) Unit 3: Basic Concepts of Sequence Alignment 14 Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Local and global alignment, pair wise and multiple sequence alignments; Similarity, identity and homology of sequences.

##### Unit 4:

Structural Bioinformatics (3-D protein, PDB), Functional genomics (genomewide and high throughput approaches to gene and protein function), Drug discovery method (Basic concepts)

##### Unit 5:

Mean, median, mode, measure of dispersion, calculation of standard deviation, standard error, Co-efficient of Variance, Chi-square test, Z test, t-Test, correlation and regression

## COMPUTATIONAL BIOLOGY

### PRACTICAL

(Credits 2)

1. Accessing biological databases
2. Retrieval of nucleotide and protein sequences from the databases.
3. To perform pair-wise alignment of sequences (BLAST) and interpret the output
4. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences
5. Predict the structure of protein from its amino acid sequence.
6. To perform a “two-sample t- test” for a given set of data
7. To learn graphical representations of statistical data with the help of computers (e.g. MS Excel).

### SUGGESTED READINGS

- Ghosh Z and Mallick B. (2008). Bioinformatics: Principles and Applications, Oxford University Press.
- Pevsner J. (2009). Bioinformatics and Functional Genomics, II Edition, Wiley Blackwell.
- Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics, Garland Science, Taylor and Francis Group, USA.
- Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc. USA
- Antonisamy, B., Christopher S. and Samuel, P. P. (2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
- Pagana, M. and Gavreau, K. (2000). Principles of Biostatistics, Duxberry Press, USA

## DSE 2(c)

### ENDOCRINOLOGY

#### THEORY

(Credits 4)

##### Unit 1:

History of endocrinology; classification, characteristics and transport of hormones; Neurosecretions and Neurohormones

##### Unit 2:

Structure of pineal gland; secretions and their functions in biological rhythms and reproduction.

Structure of hypothalamus, hypothalamic nuclei and their function; regulation of neuroendocrine glands; feedback mechanisms

Structure of pituitary gland; hormones and their functions; hypothalamo-hypophysial portal system;

##### Unit 3:

Structure of hormones; functions and regulation of thyroid gland, parathyroid, adrenal, pancreas, ovary and testis; hormones in homeostasis; disorders of endocrine glands

##### Unit 4:

Hormone action at cellular level: hormone receptors, transduction and regulation;

Hormone action at Molecular level: molecular mediators; genetic control of hormone action

##### Unit 5:

Disorders of endocrine glands; pituitary, thyroid, parathyroid, adrenal gland and pancreas.

## **ENDOCRINOLOGY**

### **PRACTICAL**

**(Credits 2)**

1. Dissect and display of Endocrine glands in laboratory bred rat\*
2. Study of the permanent slides of all the endocrine glands
3. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat\*
4. Demonstration of Castration/ ovariectomy in laboratory bred rat\*
5. Estimation of plasma level of any hormone using ELISA
6. Designing of primers of any hormone

### **SUGGESTED READINGS**

- General Endocrinology C. Donnell Turner Pub- Saunders Toppan
- Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead. Oxford: BIOS Scientific Publishers; 2001.
- Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
- Vertebrate Endocrinology by David O. Norris,

## **DSE 3(a)**

### **FISH AND FISHERIES**

#### **THEORY**

**(Credits 4)**

#### **UNIT 1:**

General description of fish; account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction.

Types of fins and their modifications; locomotion in fishes; hydrodynamics; types of Scales, use of scales in classification and determination of age of fish.

#### **UNIT 2:**

Gills and gas exchange; swim bladder: types and role in respiration, buoyancy; Osmoregulation in Elasmobranchs; reproductive strategies (special reference to Indian fishes); electric organs; bioluminescence; mechanoreceptors; Schooling; parental care; migration

#### **UNIT 3:**

Inland fisheries, marine fisheries; environmental factors influencing the seasonal variations in fish catches in the Arabian sea and the Bay of Bengal; fishing crafts and Gears; depletion of fisheries resources;

Application of remote sensing and GIS in fisheries; Fisheries law and regulations

#### **Unit 4:**

Sustainable aquaculture, extensive, semi-intensive and intensive culture of fish; pen and cage culture, polyculture, composite fish culture; brood stock management; induced breeding of fish; management of finfish hatcheries; preparation and maintenance of fish aquarium; preparation of compound diets for fish; role of water quality in aquaculture;

#### **UNIT 5:**

Transgenic fish, Zebrafish as a model organism in research; cryopreservation of gametes in fishes.

Fish diseases: bacterial, viral and parasitic; preservation and processing of harvested fish; fishery by-products

## FISH AND FISHERIES

### PRACTICAL

(Credits 2)

1. Morphometric and meristic characters of fishes
2. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera*, *Exocoetus*, *Hippocampus*, *Gambusia*, *Labeo*, *Heteropneustes*, *Anabas*
3. Study of different types of scales (through permanent slides/ photographs).
4. Study of crafts and gears used in Fisheries
5. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids
6. Study of air breathing organs in *Channa*, *Heteropneustes*, *Anabas* and *Clarias*
7. Demonstration of induced breeding in Fishes (video)
8. Demonstration of parental care in fishes (video)
9. Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

### SUGGESTED READINGS

- Q Bone and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
- D. H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
- C.B.L. Srivastava, Fish Biology, Narendra Publishing House
- J.R. Norman, A history of Fishes, Hill and Wang Publishers
- S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House

## DSE 3(b)

### IMMUNOLOGY

#### THEORY

(Credits 4)

##### Unit 1:

Historical perspective of immunology; early theories of immunology; cells and organs of the immune system

##### Unit 2:

Anatomical barriers, inflammation, cell and molecules involved in innate immunity, adaptive immunity (cell mediated and humoral), passive (artificial and natural immunity), active (artificial and natural immunity); immune dysfunctions (brief account of autoimmunity with reference to rheumatoid arthritis and tolerance, AIDS).

##### Unit 3:

Antigenicity and immunogenicity, immunogens, adjuvants and haptens; factors influencing immunogenicity, B and T-Cell epitopes

Structure and functions of different classes of immunoglobulins; antigen-antibody interactions; immunoassays (ELISA and RIA), polyclonal sera; hybridoma technology: monoclonal antibodies in therapeutics and diagnosis

##### Unit 4:

Structure and functions of MHC molecules; endogenous and exogenous pathways of antigen processing and presentation

Properties and functions of cytokines; therapeutics Cytokines

Components and pathways of complement activation.

##### Unit 5:

Gell and Coombs' classification and brief description of various types of hypersensitivities

Various types of vaccines.

## **IMMUNOLOGY**

### **PRACTICAL**

**(Credits 2)**

- 1\*. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of blood cells.
4. Ouchterlony's double immuno-diffusion method.
5. ABO blood group determination.
- 6\*. Cell counting and viability test from splenocytes of farm bred animals/cell lines.
7. Demonstration of:
  - a. ELISA
  - b. Immunoelectrophoresis

\* The experiments can be performed depending upon usage of animals in UG courses.

### **SUGGESTED READINGS**

- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company
- David, M., Jonathan, B., David, R. B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication
- Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication.

## DSE 3(c)

### PARASITOLOGY

#### THEORY

(CREDITS 4)

##### Unit I:

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*, *Plasmodium vivax*

##### Unit II:

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

##### Unit III:

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*. Study of structure, life cycle and importance of *Meloidogyne* (root knot nematode), *Pratylenca* (lesion nematode)

##### Unit IV:

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

##### Unit V:

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

## PARASITOLOGY

### PRACTICAL

(CREDITS 2)

- Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani* and *Plasmodium vivax* through permanent slides/micro photographs
- Study of adult and life stages of *Fasciolopsis buski*, *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana* through permanent slides/micro photographs
- Study of adult and life stages of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/micro photographs
- Study of plant parasitic root knot nematode, *Meloidogyne* from the soil sample
- Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs
- Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]
- Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a by product]

### Submission of a brief report on parasitic vertebrates

### SUGGESTED READINGS

- Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors
- E.R. Noble and G.A. Noble (1982) Parasitology: The biology of animal parasites. V Edition, Lea & Febiger
- Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
- Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributors, Medical Books Publishers, Chennai, Delhi
- Rattan Lal Ichhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi
- Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers
- K. D. Chatterjee (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.

## DSE 4(a)

### REPRODUCTIVE BIOLOGY

#### THEORY

(CREDITS 4)

##### **Unit 1:**

Gonadal hormones and mechanism of hormone action; steroids, glycoprotein hormones, and prostaglandins; hypothalamo – hypophyseal – gonadal axis; regulation of gonadotrophin secretion in male and female;

Development and differentiation of gonads, genital ducts, external genitalia, mechanism of sex differentiation.

##### **Unit 2:**

Outline and histology of male reproductive system in rat and human; testis: cellular functions, germ cell, stem cell renewal; spermatogenesis: hormonal regulation; androgen synthesis and metabolism; epididymal function and sperm maturation; accessory glands functions; sperm transportation in male tract

##### **Unit 3:**

Outline and histology of female reproductive system in rat and human; ovary: folliculogenesis, ovulation, corpus luteum formation and regression; steroidogenesis and secretion of ovarian hormones; reproductive cycles (rat and human) and their regulation, changes in the female tract; ovum transport in the fallopian tubes; sperm transport in the female tract, fertilization; hormonal control of implantation; hormonal regulation of gestation, pregnancy diagnosis, foeto – maternal relationship; mechanism of parturition and its hormonal regulation; lactation and its regulation

##### **Unit 4:**

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive technologies; demographic terminology used in family planning

##### **Unit 5:**

Contraceptive devices: modern contraceptive technologies; demographic technology used in family planning.

## **REPRODUCTIVE BIOLOGY**

### **PRACTICAL**

**(CREDITS 2)**

1. Study of animal house: set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear rats from live animals.
3. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliate cytology.
6. Sperm count and sperm motility in rat
7. Study of modern contraceptive devices

### **SUGGESTED READINGS**

- Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
- Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company
- Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
- Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

## DSE 4(b)

### WILD LIFE CONSERVATION AND MANAGEMENT

#### THEORY

(CREDITS 4)

##### Unit 1:

Values of wild life - positive and negative; conservation ethics; importance of conservation; causes of depletion; world conservation strategies.

##### Unit 2:

Evaluation and management of wild life;

Habitat analysis: physical parameters - topography, geology, soil and water; biological Parameters - food, cover, forage, browse and cover estimation; standard evaluation procedures: remote sensing and GIS.

Management of habitats; setting back succession; grazing logging; mechanical treatment; advancing the successional process; cover construction; preservation of general genetic diversity; restoration of degraded habitats

##### Unit 3:

Population estimation, population density, natality, birth rate, mortality, fertility schedules and sex ratio computation;

Faecal analysis of ungulates and carnivores: faecal samples, slide preparation; hair identification, pug marks and census method.

##### Unit 4:

Estimation of carrying capacity; eco tourism / wild life tourism in forests; concept of climax persistence; ecology of perturbation

##### Unit 5:

Bio- telemetry; Care of injured and diseased animal; quarantine; common diseases of wild animal

Protected areas, National parks & sanctuaries, Community reserve; important features of protected areas in India;

Tiger conservation - tiger reserves in India; management challenges.

## **WILD LIFE CONSERVATION AND MANAGEMENT**

### **PRACTICALS**

**(CREDITS 2)**

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (compass, binoculars, spotting scope, range finders, Global Positioning System, various types of cameras and lenses)
3. Familiarization and study of animal evidences in the field; identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers *etc.*
4. Demonstration of different field techniques for flora and fauna
5. PCQ, ten tree method, circular, square & rectangular plots, Parker's 2 Step and other methods for ground cover assessment, tree canopy cover assessment, shrub cover assessment.
6. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences)

### **SUGGESTED READINGS**

- Caughley, G., and Sinclair, A.R.E. (1994). *Wildlife Ecology and Management*. Blackwell Science.
- Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). *People and Wildlife, Conflict or Co-existence?* Cambridge University.
- Bookhout, T.A. (1996). *Research and Management Techniques for Wildlife and Habitats*, 5 th edition. The Wildlife Society, Allen Press
- Sutherland, W.J. (2000). *The Conservation Handbook: Research, Management and Policy*. Blackwell Sciences
- Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). *Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory*. Blackwell Publishing.

## DSE 4(c)

### COMPUTATIONAL BIOLOGY

#### THEORY

(CREDITS 4)

##### Unit 1: Introduction to biostatistics

(10 hrs)

Sampling and presentation of biological data; **Frequency distribution; Skewness and Kurtosis;** Measurement of central tendency and dispersion (mean, median, mode, variance, standard deviation and standard error)

##### Unit 2: Analytical biostatistics

(12 hrs)

Correlation and Regression analysis; Basic concept on Probability; Theoretical distribution (Binomial, Poisson and Normal distribution); Tests of significance (t test,  $\chi^2$  and F test)

##### Unit 3: Introduction to computers

(12 hrs)

Operating systems; Binary number systems; Data structure; Database concept; MS Word for word processing; MS Excel for spreadsheet; MS Access for database and MS Power Point for presentation of analytical/ field report

##### Unit 4: Computer oriented statistical techniques

(10 hrs)

Internet and Information Retrieval System; Basic idea of computer oriented environmental and ecological analysis; Understanding online databases; Flow chart and Programming techniques; Introduction to C / C<sup>++</sup>

##### Unit 5: Introduction to bioinformatics

(16 hrs)

Goal and scope for bioinformatics; Genomics; Transcriptomics; Systems biology; Metabolomics; Molecular phylogeny; Data generation and Data Retrieval: Commonly used sequencing techniques and sequence file format; Basic concept of sequence alignment; Applications and limitations of bioinformatics

## COMPUTATIONAL BIOLOGY

### PRACTICAL

(CREDITS 2)

1. Calculation of mean and standard deviation/ standard error from data provided
2. Calculation of correlation/ regression coefficient from the given biological data
3. Problems related to paired and unpaired t test/ chi-square test
4. Graphical presentation (eg. MS Excel) of biological data
5. Sequencing of pair-wise alignment (BLAST) and interpretation of output
6. Prediction of protein structure from its amino acid structure
7. Project work related to bioinformatics

## **GENERIC ELECTIVE COURSES**

### **GE 1(a)**

#### **ANIMAL CELL BIOTECHNOLOGY**

##### **THEORY**

**(CREDITS 4)**

##### **UNIT 1:**

Concept and Scope of biotechnology

Outline process of genetic engineering and recombinant DNA technology; isolation of genes; Concept of restriction and modification: restriction endonucleases, DNA modifying enzymes.

##### **UNIT2:**

Cloning vectors: plasmids, phage vectors, cosmids, phagemids, BAC, YAC, HAC, shuttle and expression Vectors.

Transformation techniques: microbial, plants and animals: Cloning in mammalian cells, Integration of DNA into mammalian genome- Electroporation and Calcium Phosphate Precipitation method.

##### **UNIT 3:**

Basic techniques in animal cell culture and organ culture, primary culture and cell lines, Culture media - natural and synthetic, stem cells, cryopreservation of cultures.

Agarose and polyacrylamide gel Electrophoresis; Southern, Northern and Western blotting, DNA sequencing: Sanger method, polymerase chain reaction, DNA Fingerprinting and DNA microarrays.

##### **UNIT 4:**

Production of transgenic animals: nuclear transplantation, retroviral method, DNA microinjection method, Dolly and Polly.

##### **UNIT 5:**

Development of recombinant vaccines, hybridoma technology, gene therapy.

Production of recombinant proteins: insulin and growth hormones;

Bio safety - physical and biological containment.

## ANIMAL CELL BIOTECHNOLOGY

### PRACTICAL

(CREDITS 2)

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation of culture media.
3. Preparation of genomic DNA from *E. coli*/animals/ human.
4. Plasmid DNA isolation (pUC 18/19) and DNA quantitation using agarose gel electrophoresis (by using lambda DNA as standard).
5. Restriction digestion of lambda ( $\lambda$ ) DNA using EcoR1 and Hind III.
6. Preparation of competent cells and Transformation of *E. coli* with plasmid DNA using CaCl<sub>2</sub>, Selection of transformants on X-gal and IPTG (Optional).
7. Techniques: Western blot, Southern hybridization, DNA Fingerprinting, PCR, DNA Microarrays

### SUGGESTED READINGS

- Animal Cells Culture and Media, D.C. Darling and S.J. Morgan, 1994. BIOS Scientific Publishers Limited.
- Methods in Cell Biology, Volume 57, Jennie P. Mathur and David Barnes, 1998. Animal Cell Culture Methods Academic Press.
- P.K. Gupta: Biotechnology and Genomics, Rastogi publishers (2003).
- B.D. Singh: Biotechnology, Kalyani publishers, 1998 (Reprint 2001).
- T.A. Brown: Gene cloning and DNA analysis: An Introduction, Blackwell Science (2001).
- Bernard R. Click & Jack J. Pasternak: Molecular Biotechnology, ASM Press, Washington (1998).
- Methods in Gene Biotechnology, W. Wu, M.J. Welsh, P.B. Kaufman & H.H. Zhang, 1997, CRC Press, New York
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA

## GE 1(b)

### ANIMAL DIVERSITY

#### THEORY

(CREDITS 4)

##### Unit 1:

General characters of Protozoa; Life cycle of *Plasmodium*

General characters and canal system in Porifera

General characters of Cnidarians and polymorphism

##### Unit 2:

General characters of Helminthes; life cycle of *Taenia solium*

General characters of Nemethehelminthes; parasitic adaptations

General characters of Annelida; metamerism.

##### Unit 3:

General characters of arthropoda; social life in insects.

General characters of mollusca; pearl formation

General characters of Echinodermata; water vascular system in starfish.

##### Unit 4:

Salient features of Protochordates

Osmoregulation, migration of fishes

General characters of Amphibia; adaptations for terrestrial life; parental care in Amphibia.

##### Unit 5:

Origin of reptiles; terrestrial adaptations in reptiles.

The origin of birds; flight adaptations

Early evolution of mammals; primates; dentition in mammals.

## ANIMAL DIVERSITY

### PRACTICAL

(CREDITS 2)

1. Study of following specimens:

**Non Chordates:** *Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon.*

**Chordates:** *Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds-(Crow, duck, Owl), Squirrel and Bat.*

2. Study of following Permanent Slides: Cross section of Sycon, Sea anemone and *Ascaris* (male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.

3. Temporary mounts of

- Septal & pharyngeal nephridia of earthworm.
- Unstained mounts of Placoid, cycloid and ctenoid scales.

4. Dissections of

- Digestive and nervous system of Cockroach.
- Urinogenital system of Rat

### SUGGESTED BOOKS

- Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
- Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach 7th Edition, Thomson Books/Cole
- Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
- Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.
- Raven, P. H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications. New Delhi.

## **GE 2(a)**

### **AQUATIC BIOLOGY**

#### **THEORY**

**(Credits 4)**

#### **UNIT 1:**

Brief introduction of the aquatic biomes: freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

#### **UNIT 2:**

Lakes: Origin and classification, lake as an ecosystem, lake morphometry, physico-chemical characteristics: light, temperature, thermal stratification, dissolved solids, carbonate, bicarbonates, phosphates and nitrates; turbidity; dissolved gases (oxygen, carbon dioxide). Nutrient cycles in Lakes-nitrogen, sulphur and phosphorous; pH of water.

#### **UNIT 3:**

Streams: different stages of stream development, physico-chemical environment, adaptation of hill-stream fishes.

#### **UNIT 4:**

Salinity and density of swater, continental shelf, adaptations of deep sea organisms, coral reefs, sea weeds.

#### **UNIT 5:**

Causes of pollution: agricultural, industrial, sewage, thermal and oil spills, eutrophication; Management and conservation (legislations), sewage treatment, water quality assessment-BOD and COD.

Nitrogen, phosphorus, potassium, pH, humus content, total  $\text{CaCO}_3$ , available lime, organic matter, total sulphur, trace elements.

## **AQUATIC BIOLOGY**

### **PRACTICAL**

**(Credits 2)**

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of turbidity/transparency, dissolved oxygen, free carbon dioxide, alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, conductivity meter, turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a sewage treatment plant/marine bioreserve/fisheries institutes.

### **SUGGESTED READINGS**

- Anathakrishnan : Bioresources Ecology 3rd Edition
- Goldman : Limnology, 2nd Edition
- Odum and Barrett : Fundamentals of Ecology, 5th Edition
- Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1st Edition
- Wetzel : Limnology, 3rd edition
- Trivedi and Goyal : Chemical and biological methods for water pollution studies
- Welch : Limnology Vols. I-II

## **GE 2(b)**

### **ENVIRONMENT AND PUBLIC HEALTH**

#### **THEORY**

**(Credits 4)**

#### **UNIT I:**

Sources of environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose response evaluation, exposure assessment.

#### **UNIT 2:**

Greenhouse gases and global warming, acid rain, ozone layer destruction, effect of climate change on public health

#### **Unit 3:**

Air, water, noise, soil pollution sources and effects; pollution control

#### **Unit 4:**

Sources of waste, types and characteristics, sewage disposal and its management, solid waste disposal, biomedical waste handling and disposal, nuclear waste handling and disposal, waste from thermal power plants, case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath.

#### **Unit 5:**

Causes, symptoms and control of tuberculosis, asthma, cholera, Minamata disease, typhoid

## **ENVIRONMENT AND PUBLIC HEALTH**

### **PRACTICAL**

**(Credits 2)**

1. To determine pH, Cl, SO<sub>4</sub>, NO<sub>3</sub> in soil and water samples from different locations.

### **SUGGESTED BOOKS**

- Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
- Kolluru Rao, Bartell Steven, Pitblado R and Stricoff “Risk Assessment and Management Handbook”, McGraw Hill Inc., New York, 1996
- Kofi Asante Duah “Risk Assessment in Environmental management”, John Wiley and sons, Singapore, 1998.
- Kasperson, J.X. and Kasperson, R.E. and Kasperson,R.E., Global Environmental Risks, V.N.University Press, New York, 2003.
- Joseph F Louvar and B Diane Louver Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey 1997.

## GE 3(a)

### EXPLORING THE BRAIN: STRUCTURE AND FUNCTION

#### **THEORY**

**(Credits 4)**

##### **Unit 1:**

Early and nineteenth century views of the brain; neuroscience today; evolution of brain in vertebrates

Neurons – soma, axon, dendrite; classification of neurons; glia – astrocytes, myelinating glia, non-neuronal cells

##### **Unit 2:**

Brain evolution and behavioral adaptation; theories of brain evolution – involving addition of structure or areas, involving new formation and reorganization of circuits.

##### **Unit 3:**

Anatomical references, cerebrum, cerebellum, brain stem, spinal cord; cranial nerves, meninges, ventricular system; CT and MRI imaging of the brain

##### **Unit 4:**

Understanding brain structure through development: formation of neural tube, primary brain vesicles; differentiation of forebrain, midbrain and hindbrain; cerebral cortex – neocortical evolution and structure-function relationship

Rhythms of the brain: electroencephalogram; sleep – why do we sleep, non REM and REM sleep, neural mechanisms of sleep; circadian rhythms.

##### **Unit 5:**

Structure and connection of the secretory hypothalamus; diffuse modulatory systems of the brain – noradrenergic, serotonergic, dopaminergic and cholinergic system; drugs and diffuse modulatory systems.

Psychosocial and biological approaches to mental illness; anxiety disorders; mood disorders; Schizophrenia.

## **EXPLORING THE BRAIN: STRUCTURE AND FUNCTION**

### **PRACTICAL**

**(CREDITS 2)**

1. Dissection and study of *Drosophila* nervous system using GFP reporter.
2. Observation and quantitation of *Drosophila* photoreceptor neurons in healthy and diseased condition.

Project work/ Home assignment

### **SUGGESTED READINGS**

- Neuroscience: Exploring the Brain by Mark F. Bear, Barry W. Connors and Michael A. Paradiso.
- Comparative vertebrate Neuroanatomy by Ann B. Butler and William Hoods.

## GE 3(b)

### FOOD, NUTRITION AND HEALTH

#### THEORY

(Credits 4)

##### Unit 1:

Food components and food-nutrients

Concept of a balanced diet, nutrient needs and dietary pattern for various groups- adults, pregnant and nursing mothers, infants, school children, adolescents and elderly

##### Unit 2:

Carbohydrates, lipids, proteins - definition, classification: their dietary source and role; vitamins - fat-soluble and water-soluble vitamins: their dietary source and importance; minerals - iron, calcium, phosphorus, iodine, selenium and zinc: their biological functions

##### Unit 3:

Introduction to health - definition and concept of health

Major nutritional deficiency diseases - protein energy malnutrition (kwashiorkor and marasmus), vitamin A deficiency disorders, iron deficiency disorders, iodine deficiency disorders- their causes, symptoms, treatment, prevention and government programmes, if any.

##### Unit 4:

Life style related diseases- hypertension, diabetes mellitus, and obesity - their causes and prevention through dietary and lifestyle modifications

Social health problems - smoking, alcoholism, drug dependence and Acquired Immuno Deficiency Syndrome (AIDS) - their causes, treatment and prevention

Common ailments- cold, cough, and fevers, their causes and treatment

##### Unit 5:

Potable water- sources and methods of purification at domestic level

Food and Water borne infections: bacterial infection: cholera, typhoid fever, dysentery;

Viral infection: hepatitis, poliomyelitis; Protozoan infection: amoebiasis, giardiasis;

Parasitic infection: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention

Brief account of food spoilage: Causes of food spoilage and their preventive measures

## FOOD, NUTRITION AND HEALTH

### PRACTICAL

(Credits 2)

1. To detect adulteration in
  - a) Ghee
  - b) Sugars
  - c) Tea leaves and
  - d) Turmeric
2. Estimation of Lactose in milk
3. Ascorbic acid estimation in food by titrimetry
4. Estimation of Calcium in foods by titrimetry
5. Study of the stored grain pests from slides/ photograph (*Sitophilus oryzae*, *Trogoderma granarium*, *Callosobruchus chinensis* and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
6. Project - undertake computer aided diet analysis and nutrition counseling for different age groups.

OR

Identify nutrient rich sources of foods (fruits and vegetables), their seasonal availability and price

OR

Study of nutrition labeling on selected foods

### SUGGESTED BOOKS

- Mudambi, SR and Rajagopal, MV. Fundamentals of Foods, Nutrition and Diet Therapy; Fifth Ed; 2007; New Age International Publishers
- Srilakshmi B. Nutrition Science; 2002; New Age International (P) Ltd.
- Srilakshmi B. Food Science; Fourth Ed; 2007; New Age International (P) Ltd.
- Swaminathan M. Handbook of Foods and Nutrition; Fifth Ed; 1986; BAPPCO.
- Bamji MS, Rao NP, and Reddy V. Text Book of Human Nutrition; 2009; Oxford & IBH Publishing Co. Pvt Ltd.
- Wardlaw GM, Hampl JS. Perspectives in Nutrition; Seventh Ed; 2007; McGraw Hill.
- Lakra P, Singh MD. Textbook of Nutrition and Health; First Ed; 2008; Academic Excellence.
- Manay MS, Shadaksharaswamy. Food-Facts and Principles; 1998; New Age International (P) Ltd.
- Gibney et al. Public Health Nutrition; 2004; Blackwell Publishing

**GE 4(a)**

**HUMAN PHYSIOLOGY**

**THEORY**

**(CREDITS 4)**

**Unit 1:**

Structure and function of digestive glands; digestion and absorption of carbohydrates, fats and proteins; nervous and hormonal control of digestion (in brief)

**Unit 2:**

Structure of neuron; propagation of nerve impulse (myelinated and non-myelinated nerve fibre);

Structure of skeletal muscle; mechanism of muscle contraction (sliding filament theory), Neuromuscular junction

**Unit 3:**

Types of respiration; mechanism of breathing and respiratory volume; transport of oxygen and carbon dioxide in blood; factors affecting transport of gases.

**Unit 4:**

Functional anatomy of kidney; mechanism and regulation of urine formation;

Structure of heart; coordination of heartbeat; cardiac cycle, ECG

**Unit 5:**

Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes);

Brief account of spermatogenesis and oogenesis; menstrual cycle

## HUMAN PHYSIOLOGY

### PRACTICAL

(CREDITS 2)

1. Preparation of temporary mounts: neurons and blood film.
2. Preparation of haemin and haemochromogen crystals.
3. Estimation of haemoglobin using Sahli's haemoglobinometer.
4. Examination of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney, thyroid, pancreas, adrenal, testis, ovary.

### SUGGESTED READINGS

- Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley and Sons, Inc.
- Widmaier, E.P., Raff, H. and Strang, K.T. (2008). Vander's Human Physiology, XI Edition, McGraw Hill.
- Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
- Marieb, E. (1998). Human Anatomy and Physiology, IV Edition, Addison-Wesley.
- Kesar, S. and Vashisht, N. (2007). Experimental Physiology, Heritage Publishers.
- Prakash, G. (2012). Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Company Ltd.

## GE 4(b)

### INSECT VECTORS AND DISEASES

#### **THEORY**

**(Credits 4)**

##### **Unit 1:**

General Features of Insects; morphological features, head – eyes, types of antennae, mouth parts w.r.t. feeding habits

##### **Unit 2:**

Brief introduction of carrier and vectors (mechanical and biological vector), reservoirs, host-vector relationship, vectorial capacity, adaptations as vectors, host Specificity  
Classification of insects up to orders; detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera

##### **Unit 3:**

Dipterans as important insect vectors – mosquitoes, sand fly, houseflies;  
Study of mosquito-borne diseases – malaria, dengue, Chikungunya, viral encephalitis, filariasis; control of mosquitoes;  
Study of sand fly-borne diseases – visceral Leishmaniasis, cutaneous Leishmaniasis, Phlebotomus fever; Study of sand fly and house fly as important mechanical vector; myiasis, Control of house fly

##### **Unit 4:**

Fleas as important insect vectors; host-specificity; study of flea-borne diseases – plague, typhus fever; control of fleas  
Bugs as insect vectors; blood-sucking bugs; Chagas disease; bed bugs as mechanical vectors; Control and prevention measures

##### **Unit 5:**

Human louse (head, body and pubic louse) as important insect vectors; Study of louse-borne diseases – typhus fever, relapsing fever, trench fever, vagabond's disease, phthiriasis; Control of human louse

## INSECT VECTORS AND DISEASES

### PRACTICAL

(CREDITS 2)

1. Study of different kinds of mouth parts of insects
2. Study of following insect vectors through permanent slides/ photographs: *Aedes*, *Culex*, *Anopheles*, *Pediculus humanus capitis*, *Pediculus humanus corporis*, *Phthirus pubis*, *Xenopsylla cheopis*, *Cimex lectularius*, *Phlebotomus argentipes*, *Musca domestica*, through permanent slides/ photographs
3. Study of different diseases transmitted by above insect vectors

**Submission of a project report on any one of the insect vectors and disease transmitted**

### SUGGESTED READINGS

- Imms, A.D. (1977). A General Text Book of Entomology. Chapman & Hall, UK
- Chapman, R.F. (1998). The Insects: Structure and Function. IV Edition, Cambridge University Press, UK
- Pedigo L.P. (2002). Entomology and Pest Management. Prentice Hall Publication
- Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases. Wiley-Blackwell

## SKILL ENHANCEMENT COURSES

### SEC 1

### APICULTURE

(CREDITS 2)

#### **Unit 1:**

History, classification and biology of honey bees;  
Social organization of bee colony

#### **Unit 2:**

Artificial bee rearing (Apiary), beehives – Newton and Langstroth  
Bee pasturage selection of bee species for apiculture  
Bee keeping equipment  
Methods of extraction of honey (indigenous and modern)

#### **Unit 3:**

Bee diseases and enemies  
Control and preventive measures

#### **Unit 4:**

Products of apiculture industry and its uses (honey, bees wax, propolis), pollen *etc*

#### **Unit 5:**

Bee keeping industry – recent efforts, modern methods in employing artificial beehives for cross pollination in horticultural gardens

### SUGGESTED READINGS

- Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
- Bisht D.S., Apiculture, ICAR Publication
- Singh S., Beekeeping in India, Indian council of Agricultural Research, NewDelhi.

## SEC – 2

### AQUARIUM FISH KEEPING

(CREDITS 2)

**Unit 1:**

The potential scope of aquarium fish industry as a cottage industry, exotic and endemic species of aquarium fishes

**Unit 2:**

Common characters and sexual dimorphism of fresh water and marine aquarium fishes such as guppy, molly, sword tail, gold fish, angel fish, blue morph, anemone fish and butterfly fish

**Unit 3:**

Use of live fish feed organisms; preparation and composition of formulated fish feeds

**Unit 4:**

Live fish transport - fish handling, packing and forwarding techniques.

**Unit 5:**

General aquarium maintenance – budget for setting up an aquarium fish farm as a cottage industry

## SEC 3

### MEDICAL DIAGNOSTICS

#### THEORY

(Credits 2)

##### Unit 1:

Introduction to medical diagnostics and its importance;

Urine analysis: physical characteristics; abnormal constituents

##### Unit 2:

Blood composition; preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain; platelet count using haemocytometer; Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.)

##### Unit 3:

Causes, types, symptoms, complications, diagnosis and prevention of diabetes (Type I and Type II); hypertension (Primary and secondary); testing of blood glucose using glucometer/Kit

##### Unit 4:

Causes, types, symptoms, diagnosis and prevention of tuberculosis, hepatitis, dengue, malaria, Japanese encephalitis

##### Unit 5:

Types of tumours (benign/malignant), detection and metastasis; medical imaging: X-Ray of bone fracture, PET, MRI and CT Scan (using photographs).

#### SUGGESTED READINGS

- Park, K. (2007), Preventive and Social Medicine, B.B. Publishers
- Godkar P.B. and Godkar D.P. Textbook of Medical Laboratory Technology, II Edition, Bhalani Publishing House
- Cheesbrough M., A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses
- Guyton A.C. and Hall J.E. Textbook of Medical Physiology, Saunders
- Robbins and Cortan, Pathologic Basis of Disease, VIII Edition, Saunders
- Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

## SEC 4

### RESEARCH METHODOLOGY

CREDITS 2

#### Unit 1:

Meaning, objectives, motivation; research methods vs methodology

Types of research: analytical vs descriptive, quantitative vs qualitative, basic vs applied

#### Unit 2:

Need for research design: features of good design, important concepts related to good design- observation and Facts, prediction and explanation, development of models.

Developing a research plan: problem identification, experimentation, determining experimental and sample designs

#### Unit 3:

Observation and collection of data; methods of data collection - sampling methods, data processing and analysis strategies;

Technical reports and thesis writing; preparation of tables and bibliography.

Data presentation using digital technology

#### Unit 4:

How to publish a research work; reference writing; plagiarism; impact factor

#### Unit 5:

Intellectual property rights; commercialization, copy right, royalty, patent law, citation, acknowledgement

### SUGGESTED READINGS

- Anthony, M, Graziano, A.M. and Raulin, M.L. 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
- Walliman, N. 2011. Research Methods- The Basics. Taylor and Francis, London, New York.
- Wadhera, B.L.: Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, 2002, Universal Law publishing
- C.R.Kothari: Research Methodology, New Age International, 2009
- Coley, S.M. and Scheinberg, C.A. 1990, "Proposal writing". Stage Publications.

## SEC 5

### SERICULTURE

(CREDITS 2)

#### Unit 1:

Sericulture: definition, history and present status; silk route; types of silkworms;  
Distribution and races; exotic and indigenous races  
Mulberry and non-mulberry sericulture

#### Unit 2:

Life cycle of *Bombyx mori*  
Structure of silk gland and secretion of silk

#### Unit 3:

Selection of mulberry variety and establishment of mulberry garden;  
Rearing house and rearing appliances; disinfectants: Formalin, bleaching powder, RKO  
Silkworm rearing technology: early age and late age rearing;  
Types of mountages; spinning, harvesting and storage of cocoons

#### Unit 4:

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates;  
Pathogenesis of silkworm diseases: protozoan, viral, fungal and bacterial;  
Control and prevention of pests and diseases

#### Unit 5:

Prospects of sericulture in India: sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture.  
Visit to various sericulture centres.

### SUGGESTED READINGS

- Manual on Sericulture; Food and Agriculture Organisation, Rome 1976
- Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore
- Silkworm Rearing and Disease of Silkworm, 1956, Ptd. By Director of Ptg., Stn. & Pub. Govt. Press, Bangalore
- Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore.

- Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co. Ltd., Tokyo, Japan 1972.
- Manual of Silkworm Egg Production; M. N. Narasimhanna, CSB, Bangalore 1988.
- Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome 1988.
- A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI, Mysore 1989.
- Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB, Bangalore, 1986.