

Revised
SYLLABUS FOR
Bachelor of Science (Honours)

ZOOLOGY

THREE YEAR DEGREE COURSE
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)

(2021)

COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Non-chordates I: Protozoans to Pseudocoelomates (Theory)	ZOC 1.11	4
		Non-chordates I: Protozoans to Pseudocoelomates (Practical)	ZOC 1.12	2
	Core 2	Principles of Ecology (Theory)	ZOC 1.21	4
		Principles of Ecology (Practical)	ZOC 1.22	2
	Generic Elective -1	Aquatic biology (Theory) OR Animal diversity (Theory)	ZOG 1.11(a) ZOG 1.11(b)	4
		Aquatic biology (Practical) OR Animal diversity (Practical)	ZOG 1.12(a) ZOG 1.12(b)	2
II	Core 3	Non-chordates II: Coelomates (Theory)	ZOC 2.11	4
		Non-chordates II: Coelomates (Practical)	ZOC 2.12	2
	Core 4	Cell Biology (Theory)	ZOC 2.21	4
		Cell Biology (Practical)	ZOC 2.22	2
	Generic Elective 2	Environmental and Public Health (Theory) OR Insect Vectors and Diseases (Theory)	ZOG 2.11(a) ZOG 2.11(b)	4
		Environmental and Public Health (Practical) OR Insect Vectors and Diseases (Practical)	ZOG 2.12(a) ZOG 2.12(b)	2
III	Core 5	Diversity of Chordates (Theory)	ZOC 3.11	4
		Diversity of Chordates (Practical)	ZOC 3.12	2
	Core 6	Physiology: Controlling and Coordinating Systems (Theory)	ZOC 3.21	4
		Physiology: Controlling and Coordinating Systems (Practical)	ZOC 3.22	2
	Core 7	Fundamentals of Biochemistry (Theory)	ZOC 3.31	4
		Fundamentals of Biochemistry (Practical)	ZOC 3.32	2
	Skill Enhancement Course 1	Apiculture OR Sericulture	ZOS 3.11(a) ZOS 3.11(b)	2
	Generic Elective 3	Human Physiology (Theory) OR Exploring the Brain: Structure and	ZOG 3.11(a) ZOG 3.11(b)	4

		Function (Theory)		
		Human Physiology (Practical) OR Exploring the Brain: Structure and Function (Practical)	ZOG 3.12(a) ZOG 3.12(b)	2
IV	Core 8	Comparative Anatomy of Vertebrates (Theory)	ZOC 4.11	4
		Comparative Anatomy of Vertebrates (Practical)	ZOC 4.12	2
	Core 9	Physiology: Life Sustaining Systems (Theory)	ZOC 4.21	4
		Physiology: Life Sustaining Systems (Practical)	ZOC 4.22	2
	Core 10	Biochemistry of Metabolic Processes (Theory)	ZOC 4.31	4
		Biochemistry of Metabolic Processes (Practical)	ZOC 4.32	2
	Skill Enhancement Course 2	Medical Diagnostics OR Aquarium Fish Keeping	ZOS 4.11(a) ZOS 4.11(b)	2
	Generic Elective 4	Food, Nutrition and Health (Theory) OR Animal Cell Biotechnology (Theory)	ZOG 4.11(a) ZOG 4.11(b)	4
		Food, Nutrition and Health (Practical) OR Animal Cell Biotechnology (Practical)	ZOG 4.12(a) ZOG 4.12(b)	2
	V	Core 11	Molecular Biology (Theory)	ZOC 5.11
Molecular Biology (Practical)			ZOC 5.12	2
Core 12		Principles of Genetics (Theory)	ZOC 5.21	4
		Principles of Genetics (Practical)	ZOC 5.22	2
Discipline Specific Elective 1		Biology of Insects (Theory) OR Animal Behaviour and Chronobiology (Theory)	ZOD 5.11(a) ZOD 5.11(b)	4
		Biology of Insects (Practical) OR Animal Behaviour and Chronobiology (Practical)	ZOD 5.12(a) ZOD 5.12(b)	2
Discipline Specific Elective 2		Parasitology (Theory) OR Reproductive Biology (Theory)	ZOD 5.21(a) ZOD 5.21(b)	4
		Parasitology (Practical) OR Reproductive Biology (Practical)	ZOD 5.22(a) ZOD 5.22(b)	2
Core 13		Developmental Biology (Theory)	ZOC 6.11	4
		Developmental Biology (Practical)	ZOC 6.12	2

VI	Core 14	Evolutionary Biology (Theory)	ZOC 6.21	4
		Evolutionary Biology (Practical)	ZOC 6.22	2
	Discipline Specific Elective 3	Fish and Fisheries (Theory) OR Wildlife Conservation and Management (Theory)	ZOD 6.11(a) ZOD 6.11(b)	4
		Fish and Fisheries (Practical) OR Wildlife Conservation and Management (Practical)	ZOD 6.12(a) ZOD 6.12(b)	2
	Discipline Specific Elective 4	Immunology (Theory) OR Endocrinology (Theory)	ZOD 6.21(a) ZOD 6.21(b)	4
		Immunology (Practical) OR Endocrinology (Practical)	ZOD 6.22(a) ZOD 6.22(b)	2

CORE COURSES	
CC I	Non-chordates I: Protozoans to Pseudocoelomates
CC II	Principles of Ecology
CC III	Non-chordates II: Coelomates
CC IV	Cell Biology
CC V	Diversity of Chordates
CC VI	Physiology: Controlling and Coordinating Systems
CC VII	Fundamentals of Biochemistry
CC VIII	Comparative Anatomy of Vertebrates
CC IX	Physiology: Life Sustaining Systems
CC X	Biochemistry of Metabolic Processes
CC XI	Molecular Biology
CC XII	Principles of Genetics
CC XIII	Developmental Biology
CC XIV	Evolutionary Biology

DISCIPLINE SPECIFIC ELECTIVE COURSES	
DSE 1	(A) Biology of Insects (or) (B) Animal behavior and chronobiology
DSE 2	(A) Parasitology (or) (B) Reproductive biology
DSE 3	(A) Fish and Fisheries (or) (B) Wildlife conservation and management
DSE 4	(A) Immunology (or) (B) Endocrinology

SKILL ENHANCEMENT COURSES	
SEC I	(A) Apiculture (or) (B) Sericulture
SEC II	(A) Medical Diagnostic (or) (B) Aquarium Fish keeping

GENERIC ELECTIVE COURSES	
GE I	(A) Aquatic biology (or) (B) Animal diversity
GE II	(A) Environment and Public Health (or) (B) Insect vectors and diseases
GE III	(A) Human Physiology (or) (B) Exploring the brain: structure and function
GE IV	(A) Food, Nutrition and Health (or) (B) Animal cell biotechnology

SEMESTER - I

CORE 1 (ZOC 1.11)

NON-CHORDATES I: PROTOZOANS TO PSEUDOCOELOMATES

Theory Credits: 4

Unit 1: Protozoa

General characteristics and classification up to classes;
Morphological study of *Euglena*, *Amoeba* and *Paramecium*;
Life cycle and pathogenicity of *Plasmodium vivax*;
Mode of locomotion, nutrition and reproduction in *Amoeba* and *Paramecium*.

Unit 2: Porifera

General characteristics and classification up to classes;
Sycon with special reference to structure, reproduction and development;
Structural organization of *leucosolenia*;
Spicules in sponges;
Canal system and affinities.

Unit 3: Cnidaria

General characteristics and classification up to classes;
Metagenesis in *Obelia*;
Aurelia with special reference to structure, reproduction, development & Polymorphism;
Polymorphism in Cnidaria;
Brief account of corals & coral reefs and their importance.

Unit 4: Ctenophora and Platyhelminthes

General characteristics and evolutionary significance of Ctenophora;
General characteristics and classification up to classes of Platyhelminthes;
Study of *Fasciola hepatica* with reference to structure, reproduction, life cycle and pathogenicity;

Unit 5: Nematelminthes

General characteristics and classification up to classes;
Study of *Ascaris* with special reference to structure reproduction, life cycle, and pathogenicity;
Life cycle and pathogenicity of *Ancylostoma duodenali*;
Parasitic adaptations in helminthes.

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

CORE 1 (ZOC 1.12)

NON-CHORDATES I: PROTOZOANS TO PSEUDOCOELOMATES

Practical Credits: 2

1. Study of whole mount of *Amoeba*, *Monocystic* and *Trypanosoma*.
2. Binary fission and conjugation in *Paramecium*
3. Culture of *Paramecium* and *Euglena*.
4. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Spongilla*, *Obelia*, *Physalia*, *Gorgonia*
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. Temporary mounting of Spicules and Gemmules.

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

Recommended Books and References:

- 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.
- Kotpal, R. L. (2005): *Modern text book of Zoology Invertebrates* (Animal Diversity-I). Rastogi Publications pp 795-831. Rastogi V. B. (2015): *Invertebrate Zoology*. Publisher- Kedar Nath Ram Nath.
- Verma, P. S. (2015): *A Manual of Practical Zoology Invertebrates*. S. Chand & Company Pvt. Ltd. Ram Nagar, New Delhi-110055.
- Yadav, V., Yadav, P. Varshney, V. K., Varshney, V. C. (2015): *Text Book of Practical Zoology-I*. Publisher- Kedar Nath Ram Nath Merrut.

CORE 2 (ZOC 1.21)
PRINCIPLES OF ECOLOGY

Theory Credits 4

Unit 1: Introduction to Ecology

Concept of Species, sympatric and allopatric species;
Law of limiting factors - Liebig's law of minimum and Shelford's law of tolerance;
History of ecology, autecology and synecology, Levels of organization;
Study of physical factors - Light, Temperature, Rainfall and Humidity.

Unit 2: Population

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;
Population regulation - density-dependent and independent factors;

Unit 3: Community

Community characteristics, vertical stratification, Ecotone and edge effect; Causes and trends of succession, Types of succession, General process of succession, Hydrosere, Lithosere, Climax concept in succession.

Unit 4: Ecosystem

Types of ecosystems with one example in detail; Food chain - detritus and grazing food chains; Food web; Energy flow through the ecosystem; Ecological pyramids; Ecological efficiencies; Biogeochemical cycle of Nitrogen and Carbon.

Unit 5: Biodiversity and Wildlife Conservation

Definition and types of biodiversity; Measurement of biodiversity; Causes of extinction; Hotspot of Indian biodiversity; Biodiversity conservation strategies; Sanctuaries, National parks and Biosphere reserves of India.

CORE 2 (ZOC 1.22)
PRINCIPLES OF ECOLOGY

Practical 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 CO₂.
4. Field Study (report on a visit to zoological park/ Mithun reserve forest/river ecosystem).

Recommended Books and References:

- 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 Press
- Sharma, P.D (2007). Ecology and Environment. Rastogi Publications.

SEMESTER - II

CORE 3 (ZOC 2.11)

NON-CHORDATES II: COELOMATES

Theory Credits 4

Unit 1: Introduction to Coelomates

Evolution and types of coelom and metamerism;
Significance of coelom and metamerism;
Level of organization.

Unit 2: Annelida and Onychophora

General characteristics and classification of Annelida up to classes;
Reproduction, locomotion and economic importance of Annelida;
Evolutionary significance of Onychophora.

Unit 3: Arthropoda

General characteristics and classification up to classes;
Vision and respiration in Arthropoda; Larval forms of crustacean;
Metamorphosis in Insects;
Social life and economics importance of honeybee.

Unit 4: Mollusca

General characteristics and classification up to classes;
Respiration in Mollusca;
Torsion and detorsion in Gastropoda;
Pearl formation in bivalves;
Evolutionary significance of Trochophore larva;

Unit 5: Echinodermata

General characteristics and classification up to classes;
Water-vascular system in Asteroidea;
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”

CORE 3 (ZOC 2.12)

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. *Dissection/model/video of digestive system, reproductive system, nervous system 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. *Temporary mount of Setae of earthworm, Radula of *Pila*

(*Subject to UGC guidelines)

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

Recommended Books and References:

- 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 4 (ZOC 2.21)
CELL BIOLOGY

Theory Credits 4

Unit 1: Overview of Cells and Plasma Membrane

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: Endomembrane System

Morphology, types, functions and formation of Endoplasmic Reticulum and Golgi Apparatus;
Lysosomes - morphology, enzyme types, polymorphism and functions; Protein sorting and Transport system (ER, Golgi Apparatus, Lysosome).

Unit 3: Mitochondria, Peroxisomes and Cytoskeleton

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis;
Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis; Peroxisomes;
Cytoskeleton: Structure and Functions; Microtubules, Microfilaments and Intermediate filaments.

Unit 4: Nucleus

Structure of Nucleus, Nuclear envelope- Nuclear pore complex; Structure and functions of nucleolus;
Chromatin: Euchromatin and Heterochromatin; Chromosome – packaging and types; Lampbrush, polytene and Supernumerary chromosomes.

Unit 5: Cell Division and Cell Signaling

Mitosis, Meiosis and their significance, Mitotic spindle and apparatus; Cell cycle and its regulation and check points, GPCR and Role of second messenger (cAMP).

CORE 4 (ZOC 2.22)
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 slide:
 - i DNA by Feulgen reaction
 - ii DNA and RNA by MGP
 - iii Mucopolysaccharides by PAS reaction
 - iv Proteins by Mercurobromophenol blue/Fast Green
5. Preparation of Polythene Chromosome from *Chironomous* Larva.
6. Study of Cell Organelles (slides/ micrograph).

Recommended Books and References:

- 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.

SEMESTER - III

CORE 5 (ZOC 3.11)

DIVERSITY OF CHORDATA

Theory Credits 4

Unit 1: Introduction to Chordates and Protochordata

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

Unit 2: Origin of Chordata and Agnatha

Echinoderm theory of origin of chordates;
Theories of Chordate Ancestry;
External morphology, habit and habitat of petromyzon;
Advanced features of vertebrates over Protochordata;
General characteristics and classification of cyclostomes up to class.

Unit 3: Pisces and Amphibia

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

Unit 4: Reptilia and Aves

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

Unit 5: Mammals and Zoogeography

General characters and classification of mammals up to order;
Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages;
Distribution of vertebrates in different zoogeographical realms.

CORE 5 (ZOC 3.12)
DIVERSITY OF CHORDATA

Practical Credits 2

1. Protochordata

Balanoglossus, Herdmania, Branchiostoma, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions.

2. Agnatha

Petromyzon, Myxine

3. Fishes

Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetradon/ 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*.

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

8. *Dissection/microphotograph/model/video of Frog- Digestive System and spinal nerve.

9. *Dissection/microphotograph/model/video of Afferent and Efferent branchial arteries of Scoliodon.

10. Temporary mount of placoid, cycloid and Ctenoid Scale of Fish.

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

(*Subject to UGC guidelines)

Recommended Books and References:

- 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 Hallgrímsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett Publishers Inc.

CORE 6 (ZOC 3.21)

ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

Theory Credits 4

Unit 1: Tissues Bone and Cartilage

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 reabsorption.

Unit 2: Nervous System

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.

Unit 3: Muscle

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: Reproductive System

Histology of testis and ovary; Physiology of male and female reproduction;
Puberty; Methods of contraception in male and female.

Unit 5: Endocrine System

Histology and Hormones secretion and their mechanism of action - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal;
Hypothalamus (neuroendocrine gland); neuroendocrine control of anterior pituitary and endocrine system.

CORE 6 (ZOC 3.22)

ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

Practical 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 and Striated muscle fibres
4. Study of permanent slides of 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
6. * Dissection of Endocrine Glands in albino mice.
7. *Dissection of reproduction system in albino mice.

(*Subject to UGC guidelines)

Recommended Books and References:

- 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 7 (ZOC 3.31)
FUNDAMENTALS OF BIOCHEMISTRY

Theory Credit: 4

Unit 1: Carbohydrates

Structure, properties and functional significance of Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates.

Unit 2: Lipids

Lipids - classification, properties and biological importance;
Fatty acids - structure, classification and salient features;
Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

Unit 3: Proteins

Amino acids: Structure, Classification and General properties of α -amino acids; Physiological importance of essential and non-essential α -amino acids;
Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins.

Unit 4: Nucleic Acids

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids;
Cot Curves; Base pairing, Denaturation and Renaturation of DNA;
Types of DNA and RNA; Complementarity of DNA, Hypo-
Hyperchromaticity of DNA.

Unit 5: Enzymes

Nomenclature and classification; Cofactors; Specificity of enzyme action;
Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting
rate of enzyme-catalyzed reactions; Multi-substrate reactions;
Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme
action.

CORE 7 (ZOC 3.32)
FUNDAMENTALS OF BIOCHEMISTRY

Practical Credit: 2

1. Qualitative tests of carbohydrates, proteins and lipids by various chemical assays.
2. Paper chromatography of amino acids.
3. Estimation of free fatty acids.
4. Action of salivary amylase under optimum conditions.
5. To study the effect of temperature and pH on enzyme activity.
6. Demonstration of proteins separation by SDS-PAGE.
7. To study the enzymatic activity.

Recommended Books and References:

- 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.

SEMESTER - IV

CORE 8 (ZOC 4.11)

COMPARATIVE ANATOMY OF VERTEBRATES

Theory Credit: 4

Unit 1: Integumentary System and Skeletal System

Structure, functions and derivatives of integument;
Overview of axial and appendicular skeleton.

Unit 2: Digestive System and Respiratory System

Alimentary canal and associated glands; dentition,
Skin, gills, lungs and air sacs; Accessory respiratory organs.

Unit 3: Circulatory System and Urinogenital System

General plan of circulation; evolution of heart and aortic arches;
Succession of kidney, Evolution of urinogenital ducts.

Unit 4: Nervous System

Comparative account of brain;
Autonomic nervous system, Spinal cord, Cranial nerves in mammals.

Unit 5: Sense Organs

Classification of receptors;
Gustatory, Olfactory, Photo, Tactile and Audio receptor in man.

CORE 8 (ZOC 4.12)
COMPARATIVE ANATOMY OF VERTEBRATES

Practical Credit: 2

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit
3. Mammalian skulls: One herbivorous and one carnivorous animal
4. Study of arterial and urinogenital system in mice with model/ chart.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted)
6. Video recording/ *demonstration of dissection on the Arterial system and Brain of Frog.

(*Subject to UGC guidelines)

Recommended Books and References:

- 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 9 (ZOC 4.21)

ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS

Theory Credit: 4

Unit 1: Physiology of Digestion

Structural organization and functions of gastrointestinal tract and associated glands;
Mechanical and chemical digestion of food;
Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins;
Hormonal control of secretion of enzymes in gastrointestinal tract.

Unit 2: Physiology of Respiration

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation;
Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood;
Respiratory pigments, Dissociation curves and the factors influencing it;
Carbon monoxide poisoning; Control of respiration.

Unit 3: Renal Physiology

Structure of kidney and its functional unit; Mechanism of urine formation;
Regulation of water balance; Regulation of acid-base balance

Unit 4: Blood

Components of blood and their functions; Structure and functions of haemoglobin;
Haemostasis; Blood clotting system, Kallikrein-Kininogen system,
Complement system & Fibrinolytic system, Haemopoiesis,
Blood groups: Rh factor, ABO and MN.

Unit 5: Physiology of Heart

Structure of mammalian heart; Coronary circulation;
Structure and working of conducting myocardial fibers, Origin and conduction of cardiac impulses,
Cardiac cycle, Cardiac output and its regulation, nervous and chemical regulation of heart rate,
Electrocardiogram, Blood pressure and its regulation.

CORE 9 (ZOC 4.22)

ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS

Practical Credit: 2

1. Determination of ABO Blood group and Rh factor.
2. Enumeration of red blood cells using haemocytometer
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals
5. Recording of blood pressure using a sphygmomanometer
6. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney

Recommended Books and References:

- 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.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

CORE 10 (ZOC 4.31)
BIOCHEMISTRY OF METABOLIC PROCESSES

Theory Credit: 4

Unit 1: Overview of Metabolism

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: Carbohydrate Metabolism

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

Unit 3: Lipid Metabolism

β -oxidation of saturated fatty acids with even and odd number of carbon atoms; omega –oxidation of fatty acids; Biosynthesis of palmitic acid; Biosynthesis of triglycerides; Ketogenesis.

Unit 4: Protein Metabolism

Catabolism of amino acids, Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

Unit 5: Oxidative Phosphorylation

Redox systems; Mitochondrial respiratory chain and Chemiosmotic theory, Inhibitors and un-couplers of Electron Transport System.

CORE 10 (ZOC 4.32)
BIOCHEMISTRY OF METABOLIC PROCESSES

Practical Credit: 2

1. Estimation of protein content by Biuret method.
2. To perform the isoelectric precipitation of casein present in milk.
3. To estimate the saponification value of oils/fats
4. Calorimetric estimation of glucose.
5. *Detection of SGOT and SGPT or GST and GSH in serum/tissue.
6. *To perform the acid and alkaline phosphatase assay from serum/tissue.

(*Subject to UGC guidelines)

Recommended Books and References:

- 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.

SEMESTER - V

CORE 11 (ZOC 5.11) MOLECULAR BIOLOGY

Theory Credit: 4

Unit 1: Nucleic Acids and DNA Replication

Watson and Crick model of DNA, types of DNA, DNA as a genetic material, DNA Replication in prokaryotes and eukaryotes, Semi-conservative, bidirectional and semi-discontinuous replication, RNA priming, replication of telomeres.

Unit 2: Transcription

Structure and types of RNA, RNA polymerase and transcription Unit, Mechanism of transcription in prokaryotes and eukaryotes, Synthesis and processing of rRNA precursor, transcription factors.

Unit 3: Translation

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: Post Transcriptional Modifications and Processing of Eukaryotic RNA

,Structure of globin mRNA, Split genes, concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of tRNA.

Unit 5: Gene Regulation and DNA Repair Mechanisms

Transcription regulation in prokaryotes; Principles of transcriptional regulation with examples from *lac* operon and *trp* operon; Transcription regulation in eukaryotes; Causes and types of DNA damage, Pyrimidine dimerization and mismatch repair.

CORE 11 (ZOC 5.12)
MOLECULAR BIOLOGY

Practical Credit: 2

1. Study of Polytene chromosomes from Chironomous / *Drosophila* larvae
2. Preparation of liquid culture medium (LB) and raise culture of *E. coli*
3. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking
4. Demonstration of antibiotic sensitivity/resistance of *E. coli* to antibiotic pressure and interpretation of results
5. Quantitative estimation of DNA and RNA
7. Study and interpretation of electron micrographs/ photograph showing
 - (a) DNA replication
 - (b) Transcription
 - (c) Split genes

Recommended Books and References:

- 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 12 (ZOC 5.21)
PRINCIPLES OF GENETICS

Theory Credit: 4

Unit 1: Mendelian Genetics and its Extension

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, Crossing Over and Chromosomal Mapping

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

Unit 3: Mutations

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 Determination and Extra-chromosomal Inheritance

Chromosomal mechanisms of sex determination in *Drosophila* and Man; Criteria for extra-chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces*, Infective heredity in *Paramecium* and Maternal effects.

Unit 5: Polygenic Inheritance, Recombination in Bacteria and Viruses and Transposable Genetic Elements

Polygenic inheritance with suitable examples;
Conjugation, Transformation and Transduction in Bacteriophage;
Transposons in bacteria, Transposons in humans.

CORE 12 (ZOC 5.22)
PRINCIPLES OF GENETICS

Practical Credit: 2

1. To study the Mendelian laws and gene interactions with reference to experiments on monohybrid, dihybrid, trihybrid, test cross and back cross.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Study of models on DNA and RNA structures.

Recommended Books and References:

- 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.

SEMESTER - VI

CORE 13 (ZOC 6.11) DEVELOPMENTAL BIOLOGY

Theory Credit: 4

Unit 1: Introduction

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

Unit 2: Early Embryonic Development

Gametogenesis - Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal); Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

Unit 3: Late Embryonic Development

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans; Placenta (Structure, types and functions of placenta).

Unit 4: Post Embryonic Development

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: Implications of Developmental Biology

Teratogenesis; Teratogenic agents and their effects on embryonic development; *In vitro* fertilization, Stem cell (ESC), Amniocentesis.

CORE 13 (ZOC 6.12)
DEVELOPMENTAL BIOLOGY

Practical Credit: 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. Report on chick embryo development / Frog embryo (in natural condition without captivity) development

Recommended Books and References:

- 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 14 (ZOC 6.21)
EVOLUTIONARY BIOLOGY

Theory Credit: 4

Unit 1:

Historical review of evolutionary concept; Lamarckism, Darwinism, Neo-Darwinism; Evidences of Evolution, geological time scale, evolution of horse; Sources of variations; Heritable variations and their role in evolution.

Unit 2:

Population genetics; Hardy-Weinberg Law, Factor influencing 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, Genetic Drift, Role of Migration and Mutation in changing allele frequencies.

Unit 3:

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 4:

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.

Unit 5:

Types, forms and parts of phylogenetic trees, Sequence alignment- pairwise and multiple sequence alignment, construction of phylogenetic trees, interpretation of trees.

CORE 14 (ZOC 6.22)
EVOLUTIONARY BIOLOGY

Practical Credit: 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.

Recommended Books and References:

- 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 SPECIFIC ELECTIVE COURSES

DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.11(a)) BIOLOGY OF INSECTA

Theory Credit: 4

Unit 1: Introduction and Insect Taxonomy

General Features of Insects;

Distribution and Success of Insects on the Earth;

Basis of insect classification; Classification of insects up to orders.

Unit 2: General Morphology of Insects

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 3: Physiology of Insects

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

Sensory receptors; Growth and metamorphosis.

Unit 4: Insect Society

Group of social insects and their social life;

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

Unit 5: Insect Plant Interaction and Vectors

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

Insects as mechanical and Biological vectors, Brief discussion on houseflies and mosquitoes as important insect vectors.

DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.12(a))
BIOLOGY OF INSECTA

Practical Credit: 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*
8. Study of any three insect pests and their damages
9. Study of any three beneficial insects and their products
10. Field study of insects and submission of a report on the insect diversity

Recommended Books and References:

- 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

**DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.11(b))
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY**

Theory Credit: 4

Unit 1: Introduction to Animal Behaviour

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 behavior.

Unit 2: Patterns of Behaviour

Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting.

Unit 3: Social and Sexual Behaviour

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: Introduction to Chronobiology

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

Unit 5: Biological Rhythm and Clocks

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-photic zeitgebers; Circannual rhythms; Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin. Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy.

DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.12(b))
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

Practical Credit: 4

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).

Recommended Books and References:

- 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 Barenz and Noble Inc. New York, USA
- Biological Rhythms: Vinod Kumar (2002) Narosa Publishing House, Delhi/ Springer-Verlag, Germany.

**DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.21(a))
PARASITOLOGY**

Theory Credit: 4

Unit 1: Introduction to Parasitology

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

Unit 2: Parasitic Protists

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

Unit 3: Parasitic Platyhelminthes

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

Unit 4: Parasitic Nematodes

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

Unit 5: Parasitic Arthropoda

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

DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.22(a))
PARASITOLOGY

Practical Credit: 2

1. Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis*, and *Trypanosoma gambiense* through permanent slides/micro photographs
2. Study of adult and life stages of *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana* through permanent slides/micro photographs
3. Study of adult and life stages of *Ascaris lumbricoides*, *Ancylostoma duodenale*, and *Trichinella spiralis* through permanent slides/micro photographs
4. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs
5. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]
6. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a byproduct]
7. Submission of a brief report on parasitic vertebrates

Recommended Books and References:

- 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.

**DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.21(b))
REPRODUCTIVE BIOLOGY**

Theory Credit: 4

Unit 1: Reproductive Endocrinology

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

Unit 2: Functional anatomy of male reproduction

Outline and histological of male reproductive system in human; Testis: Cellular functions, germ cell, system cell renewal; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; sperm maturation; Accessory glands functions; Sperm transportation in male tract.

Unit 3: Functional anatomy of female reproduction

Outline and histological of female reproductive system in human; Ovary: folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles (human) and their regulation, changes in the female tract.

Unit 4: Fertilization

Fertilization in human; 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 5: Reproductive Health

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET, IUT, ZIFT, GIFT, ICSI; Modern contraceptive technologies.

**DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.22(b))
REPRODUCTIVE BIOLOGY**

Practical Credit: 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, Ovaryectomy, 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 through *demonstration microphotograph
6. Sperm count and sperm motility in rat (*demonstration or with the aid of models, videos, chart etc)
7. Study of modern contraceptive devices

(*Subject to UGC guidelines)

Recommended Books and References:

- 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.

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.11 (a))
FISH AND FISHERIES**

Theory Credit: 4

UNIT 1: Introduction and Classification:

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

UNIT 2: Morphology and Physiology:

Types of fins and their modifications; Locomotion in fishes;
Types of Scales, Use of scales in determination of age of fish;
Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy;
Osmoregulation in Elasmobranchs; Reproductive strategies; Electric organs;
Bioluminescence; Mechanoreceptors; Migration.

UNIT 3: Fisheries

Inland Fisheries and Marine Fisheries;
Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Fisheries law and regulations.

Unit 4: Aquaculture

Different farming systems: Extensive, semi-intensive, intensive, composite/poly culture, Management of hatcheries and Brood stock;
Preparation and maintenance of fish aquarium; Role of water quality in aquaculture;
Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products.

UNIT 5: Fish in research

Transgenic fish, development and application of transgenic fish;
Zebrafish as a model organism in research;
Induced breeding of fish;

DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.12 (a))
FISH AND FISHERIES

Practical Credit: 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. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Alkalinity, Dissolved oxygen, free carbon dioxide and Water temperature.
5. Project Report on a visit to any fish farm/ pisciculture unit.

Recommended Books and References:

- 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

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.11(b))
WILD LIFE CONSERVATION AND MANAGEMENT**

Theory Credit: 4

Unit 1: Introduction to Wild Life

Values of wild life - positive and negative; Conservation ethics; Importance of conservation; Conservation Vs protection; Causes of depletion; Important International conventions & treaties on nature & conservation India's role & contribution (including VISION 2040).

Unit 2: Evaluation and management of wild life

Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, and cover estimation; Standard evaluation procedures: remote sensing and GIS;

Unit 3: 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; Strategies to reduce human-wildlife interactions.

Unit 4: Population estimation and management

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. Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animal

Unit 5: Protected areas

Institutions and their role in conservation; Eco tourism / wild life tourism; National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India.

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.12(b))
WILD LIFE CONSERVATION AND MANAGEMENT**

Practical Credit: 2

1. Demonstration of basic equipment needed in wildlife studies (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses)
2. Demonstration of different field techniques for flora and fauna
3. 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.
4. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences)

Recommended Books and References:

- 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.

**DISCIPLINE SPECIFIC ELECTIVE 4 (ZOC 6.21(a))
IMMUNOLOGY**

Theory Credit: 4

Unit 1: Overview of Immune System and Antigens

Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system; Important features of Immunogens, Adjuvants, haptens and B and T-Cell epitopes; Factors influencing immunogenicity .

Unit 2: Innate and Adaptive Immunity

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 AIDS).

Unit 3: Immunoglobulins

Antibodies (Immunoglobulins) - definition, general structure of Ig, Structure and functions of different classes of immunoglobulins; Antigen-antibody interactions, Immunoassays (Principles of ELISA and RIA), Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

Unit 4: Major Histocompatibility Complex and Cytokines

Structure and functions of MHC molecules; Endogenous and exogenous pathways of antigen processing and presentation; Properties and functions of cytokines, Therapeutics Cytokines.

Unit 5: Complement System, Hypersensitivity and Vaccines

Components and pathways of complement activation; Gell and Coombs' classification and brief description of various types of Hypersensitivities; Various types of vaccines (in use and in development).

DISCIPLINE SPECIFIC ELECTIVE 4 (ZOC 6.22(a))
IMMUNOLOGY

Practical Credit: 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. Enumeration of total count of WBC.
5. Demonstration of:
 - a. ELISA
 - b. Immunoelectrophoresis

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

Recommended Books and References:

- 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.

**DISCIPLINE SPECIFIC ELECTIVE 4 (ZOD 5.21(b))
ENDOCRINOLOGY**

Theory Credit: 4

Unit 1: Introduction to Endocrinology

Classification, Characteristic and Transport of Hormones, Neurosecretions and Neurohormones, Regulation of neuroendocrine glands.

Unit 2: Epiphysis and Hypothalamus

Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction. Structure of hypothalamus, Hypothalamic nuclei and their functions, Feedback mechanisms.

Unit 3: Pituitary glands

Structure of pituitary gland, Hormones and their functions, Hypothalamohypophysial portal system, Disorders of pituitary gland.

Unit 4: Peripheral Endocrine Glands

Structure, Hormones, Functions and Regulation of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and Testis Hormones in homeostasis, Disorders of endocrine glands.

Unit 5: Regulation of Hormone Action

Hormone action at Cellular level; Hormone receptors, transduction and regulation
Hormone action at Molecular level; Molecular mediators, Genetic control of hormone action.

DISCIPLINE SPECIFIC ELECTIVE 4 (ZOD 5.22(b))
ENDOCRINOLOGY

Practical Credit: 2

1. Study of Endocrine glands in laboratory lab through *dissection/photomicrograph/model.
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

(*Subject to UGC guidelines)

Recommended Books and References:

- 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.

SKILL ENHANCEMENT COURSES

SKILL ENHANCEMENT COURSE 1 (ZOS 3.11(a)) APICULTURE

Theory Credit: 2

Unit 1: Biology of Bees

History, Classification and Biology of Honey Bees;
Caste and Stages of development of Bees.

Unit 2: Rearing of Bees

Artificial Bee rearing (Apiary), Beehives – Langstroth;
Bee Pasturage;
Selection of Bee Species for Apiculture;
Bee Keeping Equipment;
Modern methods of Extraction of Honey.

Unit 3: Diseases and Enemies

Viral diseases and its management;
Bacterial diseases and its management ;
Fungal diseases and its management;
Protozoan diseases and its management;
Insect pest: Greater wax moth, Ants and Wasps.

Unit 4: Apiary management

Management of colonies, Bee Swarming and its Management, Collecting Swarms, Uniting Bee Colonies, Seasonal management - Honey Flow Season Management, Summer Management, Winter Management, Rainy Season/Monsoon Management.

Unit 5: Bee Economy

Benefits of beekeeping, products of honeybee – honey, pollen, beeswax, royal jelly, propolis, bee venom. Grading of honey, honey standards.

Recommended Books and References:

- 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.

SKILL ENHANCEMENT COURSE 1 (ZOS 3.11(b)) SERICULTURE

Theory Credit: 2

Unit 1: Introduction

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: Biology of Silkworm

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

Unit 3: Rearing of Silkworms

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 and Diseases

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: Entrepreneurship in Sericulture

Prospectus of Sericulture in India: Sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture. Case study of sericulture in northeast India.

Recommended Books and References:

- 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.

**SKILL ENHANCEMENT COURSE 2 (ZOC 4.11(a))
MEDICAL DIAGNOSTICS**

Theory Credit: 2

Unit 1: Diagnostics Methods Used for Analysis of Blood

Introduction to Medical Diagnostics and its Importance,
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 2: Diagnostic Methods Used for Urine Analysis

Urine Analysis: Physical characteristics; Abnormal constituents.

Unit 3: Non-infectious Diseases

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: Infectious Diseases

Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis.

Unit 5: Tumours

Types (Benign/Malignant), Detection and metastasis; Medical imaging: X-Ray of Bone fracture, PET, MRI and CT Scan (using photographs).

Recommended Books and References:

- 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.

SKILL ENHANCEMENT COURSE 2 (ZOS 4.11(b))
AQUARIUM FISH KEEPING

Theory Credit: 2

Unit1: Introduction to Aquarium Fish Keeping

The potential scope of Aquarium Fish Industry as a Cottage Industry, Exotic and Endemic species of Aquarium Fishes.

Unit 2: Biology of Aquarium Fishes

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: Food and feeding of Aquarium fishes

Use of live fish feed organisms. Preparation and composition of formulated fish feeds.

Unit 4: Fish Transportation

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

Unit 5: Maintenance of Aquarium

General Aquarium maintenance – budget for setting up an Aquarium Fish Farm as a Cottage Industry.

GENERIC ELECTIVE COURSES

GENERIC ELECTIVE COURSES 1 (ZOG 1.11(a))

AQUATIC BIOLOGY

Theory Credits: 4

UNIT 1: Aquatic Biomes

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

UNIT 2: Freshwater Biology-I

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.

UNIT 3: Freshwater Biology-II

Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

UNIT 4: Marine Biology

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

UNIT 5: Management of Aquatic Resources

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment- BOD and COD.

GENERIC ELECTIVE COURSES 1 (ZOG 1.12(a))
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. Project Report/Field study.

Recommended Books and References:

- 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

GENERIC ELECTIVE COURSES 1 (ZOG 1.11(b))
ANIMAL DIVERSITY

Theory Credits: 4

Unit 1. Protista, Porifera, Radiata and Aceolomates

General characters of Protozoa; Life cycle of Plasmodium;
General characters and canal system in Porifera;
General characters of Cnidarians and polymorphism;
General characters of Helminthes; Life cycle of *Taenia solium*.

Unit 2. Pseudocoelomates, Coelomate Protostomes

General characters of Nemethehelminthes; Parasitic adaptations;
General characters of Annelida ; Metamerism.

Unit 3. Arthropoda, Mollusca, Coelomate Deuterostomes

General characters. Social life in insects;
General characters of mollusca; Pearl Formation;
General characters of Echinodermata, Water Vascular system in Starfish.

Unit 4. Protochordata, Pisces, Amphibia

Salient features of protochordates;
Osmoregulation and Migration of Fishes;
General characters, Adaptations for terrestrial life and Parental care in Amphibia.

Unit 5. Reptiles, Aves and Mammalia

Amniotes; Origin of reptiles. Terrestrial adaptations in reptiles;
The origin of birds; Flight adaptations;
Early evolution of mammals; Primates; Dentition in mammals.

GENERIC ELECTIVE COURSES 1 (ZOG 1.12(b))
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. *Dissection or Demonstration through model/chart/video of

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

***(Subject to UGC Guidelines)**

Recommended Books and References:

- 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.

**GENERIC ELECTIVE COURSES 2 (ZOG 2.11(a))
ENVIRONMENT AND PUBLIC HEALTH**

Theory Credits: 4

Unit 1: Introduction

Sources of Environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure Assessment.

Unit 2: Climate Change

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, Effect of climate change on public health.

Unit 3: Pollution

Air, water, noise pollution sources and effects, Pollution control.

Unit 4: Waste Management Technologies

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 and Chernobyl disaster.

Unit 5: Diseases

Causes, symptoms and control of tuberculosis, Asthma, Cholera, Minamata disease, typhoid.

GENERIC ELECTIVE COURSES 2 (ZOG 2.12(a))
ENVIRONMENT AND PUBLIC HEALTH

Practical Credits: 2

1. To determine pH, Cl, SO₄, NO₃ in soil and water samples from different locations.
2. Determine the hardness of water in the given sample.
3. Determine the organic carbon in soil.
4. Project: Study of pollutants in a given locality

Recommended Books and References:

- 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.

GENERIC ELECTIVE COURSES 2 (ZOG 2.11(b))
INSECT VECTORS AND DISEASES

Theory Credits: 4

Unit 1: Introduction to Insects and Vectors

Morphological features of insects, Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits; Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity.

Unit 2: Dipteran as Disease Vectors

Dipterans as important insect vectors – Mosquitoes, Sand fly, Houseflies;
Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis;
Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sand fly;
Study of house fly as important mechanical vector, Myiasis, Control of house fly.

Unit 3: Siphonaptera as Disease Vectors

Fleas as important insect vectors; Host-specificity, Study of Flea-borne diseases – Plague, Typhus fever; Control of fleas.

Unit 4: Siphunculata as Disease Vectors

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.

Unit 5: Hemiptera as Disease Vectors

Bugs as insect vectors; Blood-sucking bugs; Chagas disease, Bed bugs as mechanical vectors, Control and prevention measures.

GENERIC ELECTIVE COURSES 2 (ZOG 2.12(b))
INSECT VECTORS AND DISEASES

Theory 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
4. Submission of a project report on any one of the insect vectors and disease transmitted

Recommended Books and References:

- 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

GENERIC ELECTIVE COURSES 3 (ZOG 3.11(a))
HUMAN PHYSIOLOGY

Theory Credits: 4

Unit 1: Digestion and Absorption of Food

Structure and function of digestive glands; Digestion and absorption of carbohydrates, fats and proteins; Role of digestive enzymes, Nervous and hormonal control of digestion (*in brief*)

Unit 2: Functioning of Excitable Tissue (Nerve and Muscle)

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: Respiratory Physiology

Ventilation, External and internal Respiration- Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Respiratory pigment, Transport of oxygen and carbon dioxide in blood, Factors affecting transport of gases.

Unit 4: Renal and Cardiovascular Physiology

Functional anatomy of kidney, Mechanism and regulation of urine formation.
Structure of heart, Coordination of heartbeat, Cardiac cycle, ECG. Blood pressure and its regulation.

Unit 5: Endocrine and Reproductive Physiology

Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), Brief account of spermatogenesis and oogenesis, Menstrual cycle.

GENERIC ELECTIVE COURSES 3 (ZOG 3.12(a))
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.

Recommended Books and References:

- 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.

GENERIC ELECTIVE COURSES 3 (ZOG 3.11(b))
EXPLORING THE BRAIN: STRUCTURE AND FUNCTION

Theory Credits: 4

Unit 1: Introduction:

Early and Nineteenth century views of the Brain; Neuroscience today; Neurons – Soma, Axon, Dendrite; Classification of Neurons;
Glia – Astrocytes, Myelinating Glia, Non-neuronal cells.

Unit 2: Evolution and Adaptation of Brain: Brain evolution and behavioral adaptation;
Theories of brain evolution – involving addition of structure or areas, involving new formation and reorganization of circuits.

Unit 3: Organization of the Brain:

Anatomical references, Cerebrum, cerebellum, brain stem, spinal cord; Cranial nerves, Meninges, ventricular system; CT and MRI imaging of the brain;
Formation of neural tube, Primary brain vesicles; Differentiation of forebrain, midbrain and hindbrain;
Cerebral cortex – neocortical evolution and structure-function relationship.

Unit 4: Chemical Control of Brain and Behaviour: Structure and connection of the secretory hypothalamus; Diffuse modulatory systems of the brain – noradrenergic, serotonergic, dopaminergic and cholinergic system; Drugs and diffuse modulatory systems.

Unit 5: Rhythms and Mental illness of the Brain:

Electroencephalogram; Sleep – why do we sleep, Non-REM and REM sleep, neural mechanisms of sleep; Circadian rhythms. Psychosocial and biological approaches to mental illness; Anxiety disorders; Mood disorders; Schizophrenia.

GENERIC ELECTIVE COURSES 3 (ZOG 3.12(b))
EXPLORING THE BRAIN: STRUCTURE AND FUNCTION

Practical Credits: 2

1. Dissection and study of *Drosophila* nervous system using GFP reporter.
2. Observation and quantization of *Drosophila* photoreceptor neurons in healthy and diseased condition.
3. Project work/ Home assignment

Recommended Books and References:

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

**GENERIC ELECTIVE COURSES 4 (ZOG 4.11(a))
FOOD, NUTRITION AND HEALTH**

Theory Credits: 4

Unit 1: Basic concept of food and nutrition

Food Components and food-nutrients;

Concept of a balanced diet, nutritional requirements and dietary pattern for infants, children, adults.

Unit 2: Nutritional Biochemistry:

Definition and Classification of Carbohydrates, Lipids, Proteins; their dietary sources and roles;

Vitamins- their dietary source and importance;

Minerals- Iron, calcium, phosphorus, iodine, selenium and zinc: their biological functions.

Unit 3: Health-I

Introduction to health- Definition and concept of health;

Protein deficiency disorders, Vitamin A deficiency disorders, Iron deficiency disorders, Iodine deficiency disorders- their causes, symptoms, treatment, prevention.

Unit 4: Health-II

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;

Unit 5: Food hygiene:

Food and water borne infections: Bacterial infection (cholera, typhoid fever, dysentery) - causative agent, mode of transmission, symptoms and prevention;

Protozoan infection (Amoebiasis, giardiasis) - causative agent, mode of transmission, symptoms and prevention;

Parasitic infection (taeniasis and ascariasis) - causative agent, mode of transmission, symptoms and prevention.

GENERIC ELECTIVE COURSES 4 (ZOG 4.12(a))
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. 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.
5. 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

Recommended Books and References:

- 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

GENERIC ELECTIVE COURSES 4 (ZOG 4.11(b))
ANIMAL CELL BIOTECHNOLOGY

Theory Credit: 4

UNIT 1: Techniques in Gene manipulation

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;

Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids, BAC, YAC, HAC. Shuttle and Expression Vectors; Construction of Genomic libraries and cDNA libraries Transformation techniques: microbial, plants and animals.

UNIT 2: Animal cell Culture

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 3: Fermentation

Different types of Fermentation: Submerged & Solid state; batch, Fed batch & Continuous; Stirred tank, Air Lift, Fixed Bed and Fluidized. Downstream Processing: Filtration, centrifugation, extraction, chromatography, spray drying and lyophilization.

UNIT 4: Transgenic Animal Technology

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

UNIT 5: Application in Health

Development of recombinant Vaccines, Hybridoma technology, Gene Therapy; Production of recombinant Proteins: Insulin and growth hormones; Bio safety Physical and Biological containment.

GENERIC ELECTIVE COURSES 4 (ZOG 4.12(b))
ANIMAL CELL BIOTECHNOLOGY

Practical Credit: 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 (λ) DNA using EcoR1 and Hind III.
6. Preparation of competent cells and Transformation of *E. coli* with plasmid DNA using CaCl₂, Selection of transformants on X-gal and IPTG (Optional).
7. Techniques: Western Blot, Southern Hybridization, DNA Fingerprinting, PCR, DNA Microarrays

Recommended Books and References:

- 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