

**Syllabus and Scheme of Examination
for
B.Sc. Honors Zoology**

Submitted
to

Utkal University
Bhubaneswar

Under

Choice Based Credit System
June 2015

SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc. ZOOLOGY HONORS

SEMESTER	CORE COURSE(14)	ABILITY ENHANCEMENT COMPULSORY COURSE (2)	SKILL ENHANCEMENT COURSE (SEC) (2)	DISCIPLINE SPECIFIC ELECTIVE DCE (4)	GENERIC ELECTIVE: (GE) (4)
I	DIVERSITY AND EVOLUTION OF NON-CHORDATA (PROTISTA TO PSEUDOCOELOMATES) (6 Credits, 100 Marks)	ENVIRONMENTAL SCIENCE (2Credits, 50 Marks)			GE-1 Food, Nutrition and Health (6 Credits, 100 Marks)
	PERSPECTIVES IN ECOLOGY (6 Credits, 100 Marks)				
II	DIVERSITY AND EVOLUTION OF NON-CHORDATA (COELOMATE NONCHORDATES) (6 Credits, 100 Marks)	ENGLISH COMMUNICATION (2Credits, 50 Marks)			GE-2 Biotechnology (Microbes to animals) (6 Credits, 100 Marks)
	PHYSIOLOGY: LIFE SUSTAINING SYSTEMS (6 Credits, 100 Marks)				
III	DIVERSITY AND DISTRIBUTION OF CHORDATA (6 Credits, 100 Marks)		SEC -1 COMMUNICATING ENGLISH/ ENGLISH WRITING (2Credits, 50 Marks)		GE-3 Biotechniques (6 Credits, 100 Marks)
	PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEM (6 Credits, 100 Marks)				
	COMPARATIVE ANATOMY OF VERTEBRATES (6 Credits, 100 Marks)				
IV	BIOCHEMISTRY OF METABOLIC PROCESSES (6 Credits, 100 Marks)		SEC -2 PUBLIC HEALTH AND HYGIENE (2Credits, 50 Marks)		GE-4 Bioinstrumentation (6 Credits, 100 Marks)
	CELL BIOLOGY (6 Credits, 100 Marks)				
	PRINCIPLES OF GENETICS (6 Credits, 100 Marks)				
V	DEVELOPMENTAL BIOLOGY (6 Credits, 100 Marks)			DSE-1 Animal Behaviour (6 Credits, 100 Marks)	
	MOLECULAR BIOLOGY (6 Credits, 100 Marks)			DSE-2 Economic Zoology (6 Credits, 100 Marks)	
VI	IMMUNOLOGY (6 Credits, 100 Marks)			DSE -3 Microbiology (6 Credits, 100 Marks)	
	EVOLUTIONARY BIOLOGY (6 Credits, 100 Marks)			DSE -4 Project (6 Credits, 100 Marks)	

SEME STER	COURSE OPTED	COURSE NAME	Credit	Marks
I	Ability Enhancement Compulsory Course-I	Environmental Science	2	50
	Core course-I	Diversity and evolution of non- chordata (protista to pseudocoelomates)	4	75
	Core Course-I Practical		2	25
	Core course-II	Perspectives in Ecology	4	75
	Core Course-II Practical		2	25
	Generic Elective -1	Food, Nutrition and Health	4	75
	Generic Elective -1 Practical/Tutorial		2	25
II	Ability Enhancement Compulsory Course-II	English communications	2	50
	Core course-III	Diversity and evolution of nonchordata (coelomate nonchordates)	4	75
	Core Course-III Practical		2	25
	Core course-IV	Physiology: Life sustaining systems	4	75
	Core Course-IV Practical		2	25
	Generic Elective -2	Biotechnology (Microbes to animals)	4	75
	Generic Elective - 2Practical		2	25
III	Core course-V	Diversity and distribution of chordates	4	75
	Core Course-V Practical		2	25
	Core course-VI	Physiology: Controlling and	4	75

		coordinating system		
	Core Course-VI Practical		2	25
	Core course-VII	Comparative anatomy of vertebrates	4	75
	Core Course-VII Practical		2	25
	Skill Enhancement Course-1	Communicative English/ English Writing	2	50
	Generic Elective -3	Biotechniques	4	75
	Generic Elective -3 Practical		2	25
IV	Core course-VIII	Biochemistry of metabolic processes	4	75
	Course-VIII Practical		2	25
	Core course-IX	Cell Biology	4	75
	Course-IX Practical		2	25
	Core course-X	Principles of Genetics	4	75
	Core Course- X Practical		2	25
	Skill Enhancement Course-2	Public health and hygiene	2	50
	Generic Elective -4	Bioinstrumentation	4	75
	GenericElective -4 Practical		2	25
V	Core course-XI	Developmental Biology	4	75
	Core Course-XI Practical		2	25
	Core course-XII	Molecular Biology	4	75
	Core Course-XIIPractical		2	25

	Discipline Specific Elective -1	Animal Behaviour	4	75
	Discipline Specific Elective -1 Practical		2	25
	Discipline Specific Elective -2	Economic Zoology	4	75
	Discipline Specific Elective- 2 Practical/Tutorial		2	25
VI	Core course-XIII	Immunology	4	75
	Core Course-XIII Practical/Tutorial		2	25
	Core course-XIV	Evolutionary Biology	4	75
	Core Course-XIV Practical/Tutorial		2	25
	Discipline Specific Elective - 3	Microbiology	4	75
	Discipline Specific Elective - 3 Practical/Tutorial		2	25
	Discipline Specific Elective-4	Project Report	6	100
Total			140	2400

CORE COURSE: ZOOLOGY
Paper I
DIVERSITY AND EVOLUTION OF NON-CHORDATA (PROTISTA TO PSEUDOCOELOMATES)

(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Phylum Protozoa, Parazoa and Metazoa

General characteristics and classification up to classes; Life cycle, pathogenicity and prophylaxis of *Plasmodium vivax*, *Trypanosoma gambiense* and *Entamoeba histolytica*; Locomotion and reproduction in Protozoa; Evolution of Parazoa and Metazoa.

Unit 2: Phylum Porifera and Ctenophora

General characteristics and classification up to classes; Canal system in sponges; General characteristics and evolutionary significance.

Unit 3: Phylum Cnidaria

General characteristics and classification up to classes; Metagenesis in *Obelia*; Polymorphism in Cnidaria; Corals and coral reefs.

Unit 4: Phylum Platyhelminthes

General characteristics and classification up to classes; Life cycle, pathogenicity and prophylaxis of *Fasciola hepatica* and *Taenia solium*; Parasitic adaptations.

Unit 5: Phylum Nematelminthes

General characteristics and classification up to classes; Life cycle, pathogenicity and prophylaxis of *Ascaris lumbricoides* and *Wuchereria bancrofti*; Parasitic adaptations.

Note: Classification to be followed from “Barnes RD (1982) Invertebrate Zoology. 5th Edition.”

PRACTICALS

Marks 25

Phylum Protozoa

1. Morphology of *Paramecium*, Binary fission and Conjugation in *Paramecium*.
2. Life stages of *Plasmodium vivax*, *Trypanosoma gambiense* and *Entamoeba histolytica* (Slides/Micro-photographs).
3. Examination of pond water for protists.

Phylum Porifera

4. Study of *Sycon* (including T.S. and L.S.), *Hyalonema*, and *Euplectella*.
5. Temporary mounts of spicules, gemmules and spongin fibres.

Phylum Cnidaria

6. Study of *Obelia*, *Physalia*, *Millepora*, *Aurelia*, Ephyra larva, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia* and *Metridium* (including T.S. and L.S.).

Phylum Ctenophora

7. Any one specimen/slide.

Phylum Platyhelminthes

8. Study of adult *Fasciola hepatica*, *Taenia solium* and their life stages (Slides/microphotographs).

Phylum Nemathelminthes

9. Study of adult *Ascaris lumbricoides*, *Wuchereria bancrofti* and their life stages (Slides/microphotographs).

Note: Classification to be followed from “Barnes RD (1982) Invertebrate Zoology. 5th Edition.”

SUGGESTED READINGS

1. Arora MP (2006) Non-Chordata-I. 1st edition. Himalaya Publishing House, New Delhi.
2. Arora MP (2008) Non-Chordata-II. 1st edition. Himalaya Publishing House, New Delhi.
3. Barnes RD (1982) Invertebrate Zoology. 6th Edition. Holt Saunders International Edition.
4. Barnes RSK, Calow P, Olive PJW, Golding DW & Spicer JI (2002) The Invertebrates: A New Synthesis. 3rd Edition. Blackwell Science, USA.
5. Barrington EJW (1979) Invertebrate Structure and Functions. 2nd Edition. ELBS and Nelson.
6. Boradale LA and Potts EA (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
7. Jordan EL and Verma PS (1963) Invertebrate Zoology. Revised Edition. S. Chand, New Delhi.
8. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.

CORE COURSE: ZOOLOGY
PAPER II
PERSPECTIVES IN ECOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Introduction to Ecology

Relevance of studying ecology; History of ecology; Autecology and synecology; Levels of organization; Laws of limiting factors; Detailed study of temperature and light as physical factors.

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; Population interactions, Gause's Principle with laboratory and field examples; Lotka-Volterra equation for competition and Predation, functional and numerical responses.

Unit 3: Community

Community characteristics: dominance, diversity, species richness, abundance, stratification; Ecotone and edge effect; Ecosystem development (succession) with example and Theories pertaining to climax community.

Unit 4: Ecosystem

Types of ecosystem; 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, Nitrogen cycle and Sulphur cycle.

Unit 5: Conservation of Biodiversity

Types of biodiversity, its significance, loss of biodiversity; Conservation strategies (in situ and ex situ); Role of ZSI, WWF, IUCN; Wildlife (Protection) Act, 1972.

PRACTICALS

Marks 25

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: fauna and flora 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. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary.

SUGGESTED READINGS

1. Colinvax PA (1993) *Ecology*. II Edition. John Wiley and Sons, Inc., USA.
2. Dash MC (1993) *Fundamentals of Ecology*. McGraw Hill Book Company, New Delhi.
3. Joshi N and Joshi PC (2012) *Ecology and Environment*. 1st Edition. Himalaya Publishing House, New Delhi.
4. Mohanty PK (2000) *Illustrated Dictionary of Biology*. Kalyani Publishers, Ludhiana.
5. Odum EP (2008) *Fundamentals of Ecology*. Indian Edition. Brooks/Cole.
6. Ricklefs, R.E., (2000). *Ecology*. 5th Edition. Chiron Press.
7. Robert Leo Smith *Ecology and field biology* Harper and Row.
8. Singh JS, Gupta SR and Singh SP (2014) *Ecology, Environmental Science and Conservation*. S. Chand, New Delhi.

CORE COURSE: ZOOLOGY
PAPER III
DIVERSITY AND EVOLUTION OF NON-CHORDATA (COELOMATE
NONCHORDATES)
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Phylum Annelida

General characteristics and classification up to classes; Evolution of Coelom; Metamerism and Excretion in Annelida.

Unit 2: Phylum Arthropoda

General characteristics and classification up to classes; Vision in Arthropoda; Respiration in Arthropoda; Moulting in insects, Metamorphosis in insects; Social life in insects (bees and termites) and Larval forms in Crustacea.

Unit 3: Phylum Onychophora

General characteristics, evolutionary significance and affinities of *Peripatus*.

Unit 4: Phylum Mollusca

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

Unit 5: Phylum Echinodermata

General characteristics and classification up to classes; Water-vascular system in Asterozoa; Larval forms in Echinodermata and Evolutionary significance (Affinities with Chordates).

Note: Classification to be followed from “Barnes, R.D. (1982). *Invertebrate Zoology*, 5th Edition, Holt Saunders International Edition.”

PRACTICAL

Marks 25

Phylum Annelida

1. Study of *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Terebella*, *Serpula*, *Chaetopterus*, *Pheretima* and *Hirudinaria*.
2. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.
3. T.S. through crop of leech.

Phylum Arthropoda

4. Study of *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, termite, louse, honeybee, silk moth, wasp and dragon fly.

Phylum Onychophora

5. Any one specimen/slide.

Phylum Mollusca

6. Study of *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Mytilus*, *Loligo*, *Sepia*, *Octopus* and *Nautilus* and *Cypraea* (cowrie).

Phylum Echinodermata

7. Study of echinoderm larvae.
8. Study of *Pentaceros*, *Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Echinocardium*, *Cucumaria* and *Antedon*.

Note: Classification to be followed from “Barnes, R.D. (1982). *Invertebrate Zoology*, 5th Edition, Holt Saunders International Edition”.

SUGGESTED READINGS

1. Arora MP (2006) Non-Chordata-I. 1st edition. Himalaya Publishing House, New Delhi.
2. Arora MP (2008) Non-Chordata-II. 1st edition. Himalaya Publishing House, New Delhi.
3. Barnes RD (1982) *Invertebrate Zoology*. 6th Edition. Holt Saunders International Edition.
4. Barnes RSK, Calow P, Olive PJW, Golding DW & Spicer JI (2002) *The Invertebrates: A New Synthesis*. 3rd Edition. Blackwell Science, USA.
5. Barrington EJW (1979) *Invertebrate Structure and Functions*. 2nd Edition. ELBS and Nelson.
6. Boradale LA and Potts EA (1961) *Invertebrates: A Manual for the use of Students*. Asia Publishing Home.
7. Jordan EL and Verma PS (1963) *Invertebrate Zoology*. Revised Edition. S. Chand, New Delhi.
8. Mohanty PK (2000) *Illustrated Dictionary of Biology*. Kalyani Publishers, Ludhiana.

CORE COURSE: ZOOLOGY
PAPER IV
PHYSIOLOGY: LIFE SUSTAINING SYSTEMS
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Digestive System

Structural organization, histology and functions of gastrointestinal tract and its associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Role of gastrointestinal hormones on the secretion and control of enzymes of gastrointestinal tract.

Unit 2: Respiratory System

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volume and capacity; Transport of oxygen in the blood; Oxygen- hemoglobin and myoglobin, dissociation curve and the factors influencing it; Carbon monoxide poisoning; Carbon dioxide transport in the blood; buffering action of blood and haemoglobin and Control of respiration.

Unit 3: Excretory System

Structure of kidney and its histological details; Renal blood supply; Mechanism of urine formation and its regulation and Regulation of acid-base balance.

Unit 4: Blood

Components of blood and their functions; Structure and functions of haemoglobin; Haemopoiesis; Haemostasis and Coagulation of blood and Disorders of blood.

Unit 5: Heart

Structure of heart; Coronary circulation; Structure of conducting and working of myocardial fibers; Origin and conduction of cardiac impulses functions of AV node; Cardiac cycle; Cardiac output and its regulation-Frank-Starling Law of the heart; Nervous and chemical regulation of heart rate; Blood pressure and its regulation and Electrocardiogram.

PRACTICAL

Marks 25

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

SUGGESTED READINGS

1. Arey LB (1974) Human Histology. 4th Edition. W.B. Saunders, USA.
2. Chatterjee CC (2008) Human Physiology. Vol. I and II. Medical Allied Agency, Kolkata.
3. Guyton AC and Hall JE (2006) Textbook of Medical Physiology. 9th Edition. W.B. Saunders Company, Philadelphia.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
5. Tortora GJ and Derrickson B (2012) Principles of Anatomy & Physiology. 13th Edition John Wiley and sons, USA.
6. Victor PE (2008) diFiore's Atlas of Histology with Functional Correlations. 12th Edition. Lippincott W. & Wilkins, USA.

CORE COURSE: ZOOLOGY
PAPER V
DIVERSITY AND DISTRIBUTION OF CHORDATA
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Protochordata and Origin of Chordates

General characters of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata; Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Introduction to Vertebrata and Agnatha

Advanced features of vertebrates over Protochordata; General characters and classification of cyclostomes up to class; Structural peculiarities and affinities of *Petromyzon* and *Myxine*.

Unit 3: Pisces and Amphibia

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

Unit 4: Reptilia and Aves

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

Unit 5: Mammals and Zoogeography

General characters and classification up to order; Affinities of Prototheria and Metatheria; Dentition in mammals; Adaptive radiation with reference to locomotory appendages; Zoogeographical realms; Theories pertaining to distribution of animals and Distribution of vertebrates in different realms.

PRACTICAL

Marks 25

1. Protochordata

1. *Balanoglossus*, *Herdmania*, *Branchiostoma* and Colonial Urochordata.
2. Sections of *Balanoglossus* through proboscis and branchiogenital regions.
3. Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions.
4. Permanent slide of spicules of *Herdmania*.

2. Agnatha

5. *Petromyzon* and *Myxine*.

3. Fishes

6. *Sphyrna*, *Pristis*, *Trygon*, *Torpedo*, *Chimaera*, *Notopterus*, *Mystus*, *Heteropneustes*, *Hippocampus*, *Exocoetus*, *Echeneis*, *Anguilla*, *Tetrodon*, *Diodon*, *Anabas* and Flat fish.

4. Amphibia

7. *Ichthyophis/Ureotyphlus*, *Necturus*, *Duttaphrynus*, *Polypedates*, *Hyla*, *Alytes* and *Salamandra*.

5. Reptiles

8. *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Draco*, *Ophiosaurus*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis* and *Crocodylus*.
9. Key for Identification of poisonous and non-poisonous snakes.

6. Aves

10. Study of six common birds from different orders.
11. Types of beaks and claws.
12. Types of feathers.

7. Mammalia

13. *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes* and *Hemiechenis*.

SUGGESTED READINGS

1. Agarwal VK (2011) Zoology for degree students. S. Chand, New Delhi.
2. Arora MP (2006) Chordata-1. 1st Edition. Himalaya Publishing House, New Delhi.
3. Hall BK and Hallgrimsson B (2008) *Strickberger's Evolution*. 4th Edition. Jones and Bartlett Publishers Inc., USA.
4. Jordan EL and Verma PS (1963) Chordate Zoology. Revised Edition. S. Chand, New Delhi.
5. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
6. Young JZ (2004) *The Life of Vertebrates*. 3rd Edition. Oxford University Press, USA.

CORE COURSE: ZOOLOGY
PAPER VI
PHYSIOLOGY – CONTROLLING AND COORDINATING SYSTEM
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Tissues and Glands, Bone and cartilage

Structure, location, function and classification of Epithelial tissue, Connective tissue, Muscular tissue, Nervous tissue; Types of glands and their functions; Structure and types of bones and cartilages; Ossification, bone growth and resorption.

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 synapsis, Synaptic transmission; Neuromuscular junction; Reflex action and its types, Reflex arc and Physiology of hearing and vision.

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 male and female reproductive systems; Puberty; Physiology of reproduction of male and female; Methods of contraception (depicted through flow chart).

Unit 5: Endocrine System

Functional Histology of endocrine glands - pineal, pituitary, thyroid, parathyroid, thymus, pancreas, adrenals; Hormones secreted by them and their mechanism of action; Gonadal hormones; Classification of hormones; Regulation of their secretion; Mode of hormone action; Signal transduction pathways utilized by steroidal and non-steroidal hormones; Hypothalamus (neuroendocrine gland), principal nuclei involved in neuroendocrine control of anterior pituitary and endocrine system and Placental hormones.

PRACTICALS

Marks 25

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex).
2. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres and nerve cells.
3. Examination of sections of mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid.

SUGGESTED BOOKS

1. Arey LB (1974) Human Histology. 4th Edition. W.B. Saunders, USA.
2. Chatterjee CC (2008) Human Physiology. Vol. I and II. Medical Allied Agency, Kolkata.
3. Guyton AC and Hall JE (2006) Textbook of Medical Physiology. 9th Edition. W.B. Saunders Company, Philadelphia.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
5. Tortora GJ and Derrickson B (2012) Principles of Anatomy & Physiology. 13th Edition John Wiley and sons, USA.
6. Victor PE (2008) diFiore's Atlas of Histology with Functional Correlations. 12th Edition. Lippincott W. and Wilkins, USA.

CORE COURSE: ZOOLOGY
PAPER VII
COMPARATIVE ANATOMY OF VERTEBRATES
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Integumentary System and Skeletal System

Structure, functions and derivatives of integument; Axial and appendicular skeletons; Jaw suspensorium in vertebrates.

Unit 2: Digestive and Respiratory System

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

Unit 3: Circulatory System

General plan of circulation; Evolution of heart and aortic arches.

Unit 4: Urinogenital System

Succession of kidney; Evolution of urinogenital ducts and Types of mammalian uteri.

Unit 5: Nervous System and Sense Organs

Comparative account of brain; Autonomic nervous system; Spinal Nerves; Spinal cord; Cranial nerves in Mammals; Classification of receptors; visual receptors, chemo-receptors and mechanoreceptors.

PRACTICAL

Marks 25

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs.
2. Disarticulated skeleton of Frog, *Varanus*, Fowl and Rabbit.
3. Carapace and plastron of turtle or tortoise.
4. Mammalian skulls (One herbivorous and one carnivorous animal).

SUGGESTED READINGS

1. Hilderbrand M and Gaslow GE. Analysis of Vertebrate Structure. John Wiley and Sons., USA.
2. Kardong KV (2005) Vertebrates' Comparative Anatomy, Function and Evolution. 4th Edition. McGraw-Hill Higher Education, New York.
3. Kent GC and Carr RK (2000) Comparative Anatomy of the Vertebrates. 9th Edition. The McGraw-Hill Companies, New York.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
5. Weichert CK and William Presch (1970) Elements of Chordate Anatomy. Tata McGraw Hill, New York.

CORE COURSE: ZOOLOGY
PAPER VIII
BIOCHEMISTRY OF METABOLIC PROCESSES
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Biomolecules

Structures and properties of important mono-, di- and polysaccharides; Fatty acids, triglycerides and steroids; and amino acids and proteins.

Unit 2: Carbohydrate Metabolism

Glycolysis; Citric acid cycle; pentose phosphate pathway; Gluconeogenesis; Shuttle systems (Malate-aspartate shuttle, Glycerol 3-phosphate shuttle); Glycogenolysis; Glycogenesis.

Unit 3: Lipid Metabolism

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

Unit 4: Protein Metabolism

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

Unit 5: Enzymes and Oxidative Phosphorylation

Kinetics and Mechanism of action of enzymes; Inhibition of enzyme action; Allosteric enzymes; Oxidative phosphorylation in mitochondria; Respiratory chain, ATP synthase, Inhibitors and Uncouplers.

PRACTICALS

Marks 25

1. Identification of unknown carbohydrates in given solutions (Starch, Sucrose, Lactose, Galactose, Glucose, Fructose).
2. Colour tests of functional groups in protein solutions.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH on the action of salivary amylase.
5. Effect of temperature on the action of salivary amylase.
6. Estimation of total protein in given solutions by Lowry's method.

SUGGESTED READINGS

1. Berg JM, Tymoczko JL and Stryer L (2007) Biochemistry. 6th Edition, W.H. Freeman and Co., New York.

2. Cox MM and Nelson DL (2008) Lehninger Principles of Biochemistry. 5th Edition. W.H. Freeman and Co., New York.
3. Devesena T (2014) Enzymology. 2nd Edition. Oxford University Press, UK.
4. Hames BD and Hooper NM (2000) Instant Notes in Biochemistry. 2nd Edition. BIOS Scientific Publishers Ltd., U.K.
5. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
6. Murray RK, Bender DA, Botham KM, Kennelly PJ, Rodwell VW and Well PA (2009) Harper's Illustrated Biochemistry. 28th Edition. International Edition. The McGraw-Hill Companies Inc., New York.

CORE COURSE: ZOOLOGY
PAPER IX
CELL BIOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Cells and Plasma Membrane

Prokaryotic and Eukaryotic cells; Mycoplasma; Virus, Viroids, Virions and Prions; Various models of plasma membrane; Transport across membranes; Cell junctions: Occluding junctions (Tight junctions), Anchoring junctions (desmosomes), Communicating junctions (gap junctions) and Plasmodesmata.

Unit 2: Endomembrane System, Mitochondria and Peroxisomes

The Endoplasmic Reticulum; Golgi apparatus; Mechanism of vesicular transport; Lysosomes; Structure and function of mitochondria: Chemi-osmotic hypothesis; Semiautonomous nature of mitochondria; Endosymbiotic hypothesis and Peroxisomes.

Unit 3: Cytoskeleton and Nucleus

Structure and functions of intermediate filament, microtubules and microfilaments; Ultra structure of nucleus; Nuclear envelope: Structure of nuclear pore complex; Chromosomal DNA and its packaging; Structure and function of Nucleolus.

Unit 4: Cell Cycle and Cell Signaling

Cell cycle, Regulation of cell cycle; Signaling molecules and their receptors.

Unit 5: Apoptosis and Cancer

Extrinsic (Death Receptor) Pathway and Intrinsic (Mitochondrial) Pathway; Growth and development of tumors and Metastasis.

PRACTICAL

Marks 25

1. Gram's staining technique for visualization of prokaryotic cells.
2. Study various stages of mitosis from permanent slides.
3. Study various stages of meiosis from permanent slides.
4. Study the presence of Barr body in human female blood cells/cheek cells. (Preparation of permanent slides).
5. Cytochemical demonstration (Preparation of permanent slides).
 - i. DNA by Feulgen reaction.
 - ii. Mucopolysaccharides by PAS reaction.
 - iii. Proteins by Mercurbromophenol blue.
 - iv. DNA and RNA by Methyl Green Pyronin.

(In practical examination, 05 marks should be of permanent slide submission; one mark each for DNA, PAS, Proteins, MGP and Barr body slide.)

SUGGESTED READINGS

1. Becker WM, Kleinsmith LJ, Hardin J and Bertoni G P (2009) The World of the Cell. 7th Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Bruce Albert, Bray Dennis, Lewis Julian, Raff Martin, Roberts Keith and Watson James (2008) Molecular Biology of the Cell. 5th Edition. Garland publishing Inc., New York.
3. Cooper GM and Hausman RE (2009) The Cell: A Molecular Approach. 5th Edition. ASM Press, Washington D.C.
4. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology. 8th Edition. Lippincott Williams and Wilkins, Philadelphia.
5. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley and Sons. Inc., USA.
6. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.

CORE COURSE: ZOOLOGY
PAPER X
PRINCIPLES OF GENETICS
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Mendelian Genetics and its Extension

Principles of inheritance; Incomplete dominance and co-dominance; Multiple alleles, Lethal alleles; Epistasis; Pleiotropy; Sex-linked inheritance.

Unit 2: Linkage, Crossing Over and Chromosomal Mapping

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 and Somatic cell hybridization.

Unit 3: Mutations

Gene mutations; Chromosomal mutations: Deletion, duplication, inversion, translocation; Aneuploidy and polyploidy; Induced versus spontaneous mutations; Backward and forward mutations; Suppressor mutations; Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached X method and DNA repair mechanisms.

Unit 4: Sex Determination and Quantitative Genetics

Chromosomal mechanisms of sex determination; Sex-linked, sex-influenced and sex limited characters; Polygenic inheritance and Transgressive variation.

Unit 5: Extra-chromosomal Inheritance

Criteria for extra-chromosomal inheritance; Antibiotic resistance in *Chlamydomonas*; Mitochondrial mutations and Maternal effects.

PRACTICAL

Marks 25

1. To study the Mendelian laws and gene interactions and their verification by Chi-square analyses using seeds/beads/*Drosophila*.
2. Identification of various mutants of *Drosophila*.
3. To calculate allelic frequencies by Hardy-Weinberg Law.
4. Linkage maps based on data from crosses of *Drosophila*.
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.
7. Preparation of polytene chromosomes from larva of *Chironomus/Drosophila*.
8. To study mutagenicity in *Salmonella/E. coli* by Ames test.

SUGGESTED READINGS

1. Gardner EJ, Simmons MJ, Snustad DP (2008) Principles of Genetics. 8th Edition. Wiley India.
2. Griffiths AJF, Wessler SR, Lewontin RC and Carroll SB. Introduction to Genetic Analysis. 9th Edition. W. H. Freeman and Co., New York.
3. Klug WS, Cummings MR, Spencer CA and Palladino MA (2012) Concepts of Genetics. 10th Edition. Pearson Education, Inc., USA.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
5. Russell PJ (2009) Genetics- A Molecular Approach. 3rd Edition. Benjamin Cummings, USA.
6. Snustad DP and Simmons MJ (2012) Principles of Genetics. 6th Edition. John Wiley and Sons Inc., USA.
7. Verma PS and Agarwal VK (2010) Genetics. 9th Edition. S. Chand, New Delhi.

CORE COURSE: ZOOLOGY
PAPER XI
DEVELOPMENTAL BIOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Introduction

History and basic concepts: Epigenesis, preformation, Mosaic and regulative development; Discovery of induction; 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: Changes in gametes, monospermy and polyspermy; Planes and patterns of cleavage; Early development of frog and chick up to gastrulation; Fate maps; Embryonic induction and organizers.

Unit 3: Late Embryonic Development

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

Unit 4: Post Embryonic Development

Metamorphosis: Changes, hormonal regulations in amphibians; Regeneration: Modes of regeneration (epimorphosis, morphallaxis and compensatory regeneration); Ageing: Concepts and models.

Unit 5: Implications of Developmental Biology

Teratogenesis: Teratogenic agents and their effects on embryonic development; *in vitro* Fertilization; Stem cell culture and Amniocentesis.

PRACTICAL

Marks 25

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 developmental stages (above mentioned) by raising chick embryo in the laboratory.
4. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
5. Study of different types of placenta.

6. Project report on *Drosophila* culture/chick embryo development.

SUGGESTED READINGS

1. Balinsky BI and Fabian BC (1981) An Introduction to Embryology. 5th Edition. International Thompson Computer Press.
2. Gilbert SF (2010) Developmental Biology. 9th Edition. Sinauer Associates, Inc., USA.
3. Kalthoff (2008) Analysis of Biological Development. 2nd Edition. McGraw-Hill, New York.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
5. Wolpert L, Beddington R, Jessell T, Lawrence P, Meyerowitz E and Smith J (2002) Principles of Development. 1st Edition, Oxford University Press, New York.

CORE COURSE: ZOOLOGY
PAPER XII
MOLECULAR BIOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Nucleic Acids and DNA Replication

Salient features of DNA double helix; Watson and Crick model of DNA; DNA denaturation and renaturation; DNA topology - linking number and DNA topoisomerases; Cot curves; Structure of RNA, tRNA and DNA and RNA associated proteins; DNA Replication in prokaryotes and eukaryotes; Mechanism of DNA replication; Role of proteins and enzymes in replication; Licensing factors; Semi-conservative, bidirectional and semi-discontinuous replication; RNA priming; Replication of circular and linear *ds*-DNA and replication of telomeres.

Unit 2: Transcription

RNA polymerase and transcription Unit; Mechanism of transcription in prokaryotes and Eukaryotes; Synthesis of rRNA and mRNA; Transcription factors and regulation of transcription.

Unit 3: Translation

Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; Process of protein synthesis in prokaryotes: Ribosome structure and assembly in prokaryotes, fidelity of protein synthesis, aminoacyl tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; 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.

Unit 5: Gene Regulation and Regulatory RNAs

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from *lac* operon and *trp* operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencers elements; Gene silencing, Genetic imprinting; Ribo-switches, RNA interference, miRNA and siRNA.

PRACTICAL

Marks 25

1. Study of DNA replication using Photographs or slides and special cases, e.g., Polyteny using permanent slides of polytene chromosomes.
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.

SUGGESTED READINGS

1. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) *The World of the Cell*. 7th Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2008) *Molecular Biology of the Cell*, 4th Edition. Garland publishing Inc., New York.
3. Cooper GM and Hausman RE (2007) *The Cell: A Molecular Approach*. 4th Edition, ASM Press, USA.
4. De Robertis EDP and De Robertis EMF (2006) *Cell and Molecular Biology*. 8th Edition. Lippincott Williams and Wilkins, Philadelphia.
5. Karp G (2010) *Cell and Molecular Biology: Concepts and Experiments*. 6th Edition. John Wiley and Sons. Inc., USA.
6. Mohanty PK (2000) *Illustrated Dictionary of Biology*. Kalyani Publishers, Ludhiana.

CORE COURSE: ZOOLOGY
PAPER XIII
IMMUNOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: Immune System and Immunity

Historical perspective of Immunology, Early theories of Immunology, Haematopoiesis, Cells and organs of the Immune system; 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 and Immune dysfunctions.

Unit 2: Antigens

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T - Cell epitopes.

Unit 3: Immunoglobulins

Structure and functions of different classes of immunoglobulins, Antigen-antibody interactions, Immunoassays, Polyclonal sera, Monoclonal antibodies and Hybridoma technology.

Unit 4: Major Histocompatibility Complex and Complement System

Structure and functions of endogenous and exogenous pathway of antigen presentation; Components and pathways of complement activation.

Unit 5: Cytokines, Hypersensitivity and Vaccines

Properties and functions of cytokines; Cytokine-based therapies; Gell and Coombs' classification and Brief description of various types of hypersensitivities; Types of vaccines: Recombinant vaccines and DNA vaccines.

PRACTICAL

Marks 25

1. Demonstration of lymphoid organs.
2. Ouchterlony's double immuno-diffusion method.
3. Determination of ABO blood group.
4. Preparation of single cell suspension of splenocytes from chick spleen, cell counting and viability test.
5. ELISA/ dot Elisa (using kit).
6. Principles, experimental set up and applications of immuno-electrophoresis, RIA, F.

SUGGESTED READINGS

1. Abbas KA and Lichtman HA (2003) Cellular and Molecular Immunology. 5th Edition. Saunders Publication, Philadelphia.
2. David M, Jonathan B, David RB and Ivan R (2006) Immunology. 7th Edition. Elsevier Publication, USA .
3. Kindt TJ, Goldsby RA, Osborne BA and Kuby J (2006) Immunology. 6th Edition. W.H. Freeman and Company, New York.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.

CORE COURSE: ZOOLOGY
PAPER XIV
EVOLUTIONARY BIOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)

THEORY
LECTURES: 60

Marks 75

Unit 1: History of Life, theories of Evolution and Extinction

Chemogeny, Biogeny, RNA World, Major Events in History of Life; Lamarckism; Darwinism; Neo-Darwinism; Background of extinction, Mass extinction (Causes, Names of five major extinctions, K-T extinction in detail) and Role of extinction in evolution.

Unit 2: Evidences of Evolution

Fossils and its types; Dating of fossils, Phylogeny of horse and human; Molecular evidences (Globin gene families as an example) and Molecular clock concept.

Unit 3: Processes of Evolutionary Change

Organic variations; Isolating mechanisms; Natural selection (Industrial melanism, Pesticide/Antibiotic resistance); Types of natural selection (Directional, Stabilizing, Disruptive), Sexual Selection and Artificial selection.

Unit 4: Principles of population genetics

Concept of gene pool, Gene frequencies – equilibrium frequency (Hardy-Weinberg equilibrium), Shift in gene frequency without selection – Genetic drift, Mutation pressure and Gene flow and Shifts in gene frequencies with selection.

Unit 5: Species Concept and Evolution above species level

Biological concept of species (Advantages and Limitations); Sibling species, Polymorphic species, Polytypic species, Ring species; Modes of speciation (Allopatric, Sympatric); Macro-evolutionary Principles (Darwin's Finches); Convergence, Divergence and Parallelism.

PRACTICAL

Marks 25

1. Study of fossil evidences from plaster cast models and pictures.
2. Study of homology and analogy from suitable specimens/ pictures.
3. Demonstration of changing allele frequencies with and without selection.
4. Construction of cladogram based on morphological characteristics.
5. Construction of phylogenetic tree with bioinformatics tools (Clustal X and Phylip).
6. Interpretation of phylogenetic trees.

SUGGESTED READINGS

1. Barton NH, Briggs DEG, Eisen JA, Goldstein DB and Patel NH (2007) Evolution. Cold Spring Harbour Laboratory Press.
2. Campbell NA and Reece JB (2011) Biology. 9th Edition. Pearson Education Inc., New York.
3. Douglas JF (1997) Evolutionary Biology. Sinauer Associates, USA.
4. Hall BK and Hallgrimsson B (2008) Evolution. 4th Edition. Jones and Bartlett Publishers, USA.
5. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
6. Pevsner J (2009) Bioinformatics and Functional Genomics. 2nd Edition. Wiley-Blackwell, USA.
7. Ridley M (2004) Evolution. 3rd Edition. Blackwell Publishing, USA.

**DISCIPLINE SPECIFIC ELECTIVE
ANIMAL BEHAVIOUR
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 75

Unit 1: Introduction and Mechanisms of Behaviour

Origin and history of Ethology; Brief profiles of Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate behavior; Objective of behaviour, Behaviour as a basis of evolution; Behaviour as a discipline of science; Innate behaviour, Instinct, Stimulus filtering, Sign stimuli and Code breakers.

Unit 2: Patterns of Behaviour

Reflexes: Types of reflexes, reflex path, characteristics of reflexes (latency, after discharge, summation, fatigue, inhibition) and its comparison with complex behavior.

Orientation: Primary and secondary orientation; kinesis-orthokinesis, klinokinesis; taxistropotaxis and klinotaxis and menotaxis (light compass orientation) and mnemotaxis.

Learning: Associative learning, classical and operant conditioning, Habituation and Imprinting.

Unit 3: Social Behaviour

Insects' society; Honey bee: Society organization, polyethism, foraging, round dance, waggle dance, Experiments to prove distance and direction component of dance, learning ability in honey bee, formation of new hive/queen; Reciprocal altruism, Hamilton's rule and inclusive fitness with suitable examples.

Unit 4: Sexual Behaviour

Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Infanticide, Consequences of mate choice for female fitness, Sexual conflict for male versus female parental care and Courtship behaviour in three spine stickleback.

Unit 5: Biological Clocks

Circadian rhythm, Tidal rhythm, Lunar rhythm, Advantages of biological clocks, Jet lag and Entrainment.

PRACTICAL

Marks 25

1. To study different types of animal behaviour such as habituation, social life, courtship behaviour in insects, and parental care from short videos/movies and prepare a short report.
2. To study nests and nesting habits of the birds and social insects.
3. To study the behavioural responses of wood lice to dry condition.
4. To study behavioural responses of wood lice in response to humid condition.
5. To study geotaxis behaviour in earthworm.
6. To study the phototaxis behaviour in insect larvae.
7. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.

SUGGESTED READINGS

1. David McF. Animal Behaviour. Pitman Publishing Limited, London, UK.
2. John A (2001) Animal Behaviour. 7th Edition. Sinauer Associate Inc., USA.
3. Manning A and Dawkins MS. An Introduction to Animal Behaviour. Cambridge University Press, USA.
4. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
5. Paul WS and John A (2013) Exploring Animal Behaviour. 6th Edition. Sinauer Associate Inc., Massachusetts, USA.

**DISCIPLINE SPECIFIC ELECTIVE
ECONOMIC ZOOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 75

Unit 1: Bee-keeping and Bee Economy (Apiculture)

Varieties of honey bees and Bee pasturage; Setting up an apiary: Langstroth's/Newton's hive, bee veil, brood and storage chambers, iron frames and comb sheets, drone excluder, rearing equipments, handling of bees, artificial diet; Diseases of honey bee, American and European Foulbrood, and their management; Honey extraction techniques; Physico-chemical analysis of honey; Other beneficial products from bee; Visit to an apiculture institute and honey processing Units.

Unit 2: Silk and Silk Production (Sericulture)

Different types of silk and silkworms in India; Rearing of *Bombyx mori*, Rearing racks and trays, disinfectants, rearing appliances, black boxing, Chawki rearing, bed cleaning, mountages, harvesting of cocoons; Silkworm diseases: Pebrine, Flacherie, Grasserie, Muscardine and Aspergillosis, and their management; Silkworm pests and parasites: Uzi fly, Dermestid beetles and their management; Silk reeling techniques and Quality assessment of silk fibre.

Unit 3: Aquaculture I

Brood stock management; Induced breeding of fish; Management of hatchery of fish; Management of nursery, rearing and stocking ponds; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish; Fishery by-products.

Unit 4: Aquaculture II

Prawn farming; Culture of crab; Pearl culture and Culture of air breathing fishes.

Unit 5: Dairy and Poultry Farming

Introduction; Indigenous and exotic breeds; Rearing, housing, feed and rationing; Commercial importance of dairy and poultry farming; Varietal improvement techniques; Diseases and their management; Dairy or poultry farm management and business plan; Visit to any dairy farm or Poultry farm.

* Submission of report on anyone field visits mentioned above.

PRACTICAL

Marks 25

1. Study of different types of bees (Queens, Drones and Worker bees).
2. Study of different types of silk moths.
3. Study of different types of pearls.
4. Study of different types of fish diseases.
5. Identification of different types of scales in fishes.
6. Study of different types of fins.
7. Study of different modified structures of fishes (Saw of sawfish, Hammer of hammer head fish, tail of sharks etc.)
8. Identification of various types of natural silks.

SUGGESTED READINGS

1. Dhyan Singh Bisht, Apiculture, ICAR Publication.
2. Dunham RA (2004) Aquaculture and Fisheries Biotechnology – Genetic Approaches. CABI publications, U.K.
3. Hafez ESE (1962) Reproduction in Farm Animals. Lea and Fabiger Publishers.
4. Knobil E and Neill JD (2006) The Physiology of Reproduction. Vol. 2. Elsevier Publishers, USA.
5. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
6. Prost PJ (1962) Apiculture. Oxford and IBH, New Delhi.
7. Singh S. Beekeeping in India, Indian council of Agricultural Research, New Delhi.
8. Srivastava CBL (1999) Fishery Science and Indian Fisheries. Kitab Mahal publications, India.

**DISCIPLINE SPECIFIC ELECTIVE
MICROBIOLOGY
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 75

- Unit 1:** History of Microbiology; Microbial World – Characterization, Classification and identification of microbes.
- Unit 2:** Prokaryotes: General morphology and classification of bacteria, their characters and economic importance; Gram-positive and Gram-negative bacteria.
- Unit 3:** Eukaryotes: General morphology of Protista and Fungi – classification and economic importance.
- Unit 4:** Viruses: structure, genome, replication cycle; Epidemiology of infectious diseases with reference of human hosts – Bacterial (Tuberculosis), Viral (Hepatitis), Protozoan (Amoebiasis) and Fungal (any one) disease.
- Unit 5:** Microbe interactions-Immune Responses-Antibiotics and other chemotherapeutic agents; Applied microbiology in the fields of food, agriculture, industry and environment.

PRACTICAL

Marks 25

1. Cleaning of glasswares, sterilisation principle and methods - moist heat - dry heat and filtration methods.
2. Media preparation: Liquid media, Solid media, Agar slants, Agar plates. Basal, enriched, selective media preparation - quality control of media, growth supporting properties, sterility check of media.
3. Pure culture techniques: Streak plate, pour plate and decimal dilution.
4. Cultural characteristics of microorganisms: Growth on different media, growth characteristics and description and demonstration of pigment production.
5. Staining techniques: Smear preparation, simple staining, Gram's staining, Acid fast staining and staining for metachromatic granules.
6. Morphology of microorganisms.
7. Antibiotic sensitivity testing: Disc diffusion test - Quality control with standard strains
8. Physiology characteristics: IMViC test, H₂S, Oxidase, catalase, urease test, Carbohydrate fermentation, Maintenance of pure culture, Paraffin method, Stab culture and maintenance of mold culture.

SUGGESTED READINGS

1. Ahsan J and Sinha SP (2010) A Hand book on Economic Zoology. S Chand, New Delhi.
2. Arora DR and Arora B (2001) Medical Parasitology. 2nd Edition. CBS Publications and Distributers.
3. Atwal AS (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, Ludhiana.

4. Dubey RC and Maheshwari DK (2013) A Textbook of Microbiology. S. Chand, New Delhi.
5. Dunham RA (2004) Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications.
6. Pelczar MJ, Chan ECS and Krieg NR (1993) Microbiology. 5th Edition, Tata McGraw Hill Publishing Co.Ltd.
7. Pradhan, S (1983) Insect Pests of Crops. National Book Trust of India, New Delhi.
8. Shukla, G.S. and Upadhya, V.B. (2013) Economic Zoology. 5th Edition, Rastogi Publications, Meerut.

**SKILL ENHANCEMENT COURSES
PUBLIC HEALTH AND HYGIENE
(Credits 2)**

Lectures: 30

Marks 50

Unit 1: Scope of Public health and Hygiene; nutrition and health; classification of foods; Nutritional deficiencies; Vitamin deficiencies.

Unit 2: Pollution: water pollution, air pollution, soil pollution, noise pollution, thermal pollution and radioactive pollution.

Unit 3: Environment and Health hazards; Environmental degradation and health hazards due to pollutants.

Unit 4: Communicable diseases and their control measures such as Measles, Polio, Chikungunya, Rabies, Plague, Leprosy and AIDS.

Unit 5: Non-Communicable diseases and their preventive measures such as Hypertension, Coronary Heart diseases, Stroke, Diabetes, Obesity and Mental ill-health.

SUGGESTED READINGS

1. Arora DR and Arora B (2001) Medical Parasitology. 2nd Edition. CBS Publications and Distributers.
2. Dubey RC and Maheshwari DK (2013) A text book of Microbiology. S. Chand, New Delhi.
3. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
4. Pelczar MJ, Chan ECS and Krieg NR (1993) Microbiology. 5th Edition. Tata McGraw Hill Publishing Co. Ltd.

**ELECTIVE GENERIC
FOOD, NUTRITION AND HEALTH
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 75

- Unit 1:** Food; Diet; Nutrient; Vitamins; Disorders due to deficiency of vitamins; Synthetic foods and drinks.
- Unit 2:** Functions of food; Components of food; Nutrients (Macro and micronutrients): their biochemical role and dietary sources; Food groups and the concept of a balanced diet; Causes of food spoilage; Food adulteration; Nutrition through the life cycle- Physiological considerations, nutrient needs and dietary pattern for various groups- adults, pregnant and nursing mothers, infants, preschool and school children, adolescents and elderly.
- Unit 3:** Nutritional Biochemistry Carbohydrates, Lipids, Proteins - Definition, Classification, Structure and properties Significance of acid value, iodine value and saponification value of lipids; Essential and Non-essential amino acids; Enzymes- Definition, Classification, Properties; Coenzymes Vitamins- Fat-soluble and Water-soluble vitamins; their Structure and properties Minerals- Iron, calcium, phosphorus, iodine, selenium and zinc and their properties.
- Unit 4:** Introduction to health- Definition and concept of health; Major nutritional deficiency Diseases: Protein Energy Malnutrition; Life style related diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention through dietary or lifestyle modifications. Social health problems- smoking, alcoholism, drug dependence and Acquired Immuno Deficiency Syndrome (AIDS); Common ailments- cold, cough, fevers, diarrhoea, constipation: their causes and dietary treatment.
- Unit 5:** Food hygiene, Potable water- sources and methods of purification, Food and Water borne Infections.

PRACTICALS

Marks 25

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric.
2. To determine absorbed oil content in fried foods.
3. Estimation of lactose in milk.
4. Ascorbic acid estimation in food by titrimetry.
5. Estimation of calcium in foods by titrimetry.
6. Preparation of temporary mounts of various stored grain pests.
7. Project- Undertake computer aided diet analysis and nutrition counselling for different age groups. OR Identify nutrient rich sources of foods, their seasonal availability and price; study of Nutrition labelling on selected foods.

SUGGESTED BOOKS

1. Bamji MS, Rao NP and Reddy V (2009) Text Book of Human Nutrition. Oxford & IBH Publishing Co. Pvt Ltd.
2. Jain P et al. (2007) Poshanvaswasthyakemooolsiddhant (Hindi). 1st Ed. Academic Pratibha.
3. Lakra P and Singh MD (2008) Textbook of Nutrition and Health. 1st Edition. Academic Excellence.
4. Manay MS, Shadaksharaswamy (1998) Food-Facts and Principles. New Age International (P) Ltd.
5. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
6. Mudambi SR and Rajagopal MV (2007) Fundamentals of Foods, Nutrition and Diet Therapy. 5th Edition. New Age International Publishers.
7. Srilakshmi B (2002) Nutrition Science. New Age International (P) Ltd.
8. Srilakshmi B (2007) Food Science. 4th Edition. New Age International (P) Ltd.
9. Swaminathan M (1986) Handbook of Foods and Nutrition. 5th Edition. BAPPCO.
10. Wardlaw GM, Hampl JS (2007) Perspectives in Nutrition. 7th Edition. McGraw Hill.

**ELECTIVE GENERIC
BIOTECHNOLOGY: MICROBES TO ANIMALS
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 75

Unit 1: Introduction

Concept and scope of Biotechnology; Importance of biotechnology and Application of biotechnology.

Unit 2: Techniques in Gene Manipulation

Restriction and modifying enzymes, Cloning vectors and Expression vectors, Transformation techniques, Identification of recombinants, Construction and screening of DNA libraries; Molecular analysis of DNA, RNA and proteins (*i.e.*, Southern, Northern and Western blotting), DNA sequencing (Sanger's method and automation), Polymerase Chain Reaction, Microarrays, DNA fingerprinting and RAPD.

Unit 3: Microbes in Biotechnology

Growth kinetics of microbes, Applications of microbes in industry (Concept of primary and secondary metabolites, Fermentation/Bioreactors, Downstream processing), Bioremediation and Biosensing.

Unit 4: Transgenic Animal

Production of transgenic animals: Retroviral method, DNA microinjection method, embryonic stem cell method, nuclear transplantation; Applications of transgenic animals; Knockout mice; Transgenic livestock and Transgenic fish.

Unit 5: Biotechnology and Human Welfare

Animal cell technology: Concept of expressing cloned genes in mammalian cells, Recombinant DNA in health (Recombinant insulin and human growth hormone), Production of recombinant vaccines, Gene therapy: *in vitro*, *in-vivo* and *ex-vivo*. Ethical issues concerning: Transgenesis, Biosafety and Intellectual Property Rights.

PRACTICAL

Marks 25

1. Isolation of genomic DNA from *E. coli* and analyze it using agarose gel electrophoresis.
2. Isolation of plasmid DNA (pUC 18/19) and analyse it using agarose gel electrophoresis.
3. Transformation of *E. coli* (pUC 18//19) and calculation of transformation efficiency.
4. Restriction digestion of lambda (λ) DNA using *EcoR1* and *Hind III*.
5. DNA ligation (lambda DNA *EcoR1/Hind III* digested).
6. Construction of restriction digestion maps from data provided.
7. Study of Southern blot hybridization and PCR; Analysis of DNA fingerprinting (Dry Lab).
8. Project on Animal Cell Culture.

SUGGESTED READINGS

1. Beauchamp TI and Childress JF (2008) Principles of Biomedical Ethics. 6th Edition. Oxford University Press, USA.
2. Brown TA (1998) Molecular Biology Labfax II: Gene Cloning and DNA Analysis. 2nd Edition. Academic Press, USA.
3. Glick BR and Pasternak JJ and Patten CL (2009) Molecular Biotechnology - Principles and Applications of Recombinant DNA. 4th Edition. ASM press, Washington, USA.
4. Griffiths AJF, Miller JH, Suzuki DT, Lewontin RC and Gelbart WM (2009) An Introduction to Genetic Analysis. 9th Edition. W.H. Freeman and Co., USA.
5. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
6. Snustad DP and Simmons MJ (2009) Principles of Genetics. 5th Edition, John Wiley and Sons Inc., USA.
7. Watson JD, Myers RM, Caudy A and Witkowski JK (2007) Recombinant DNA- Genes and Genomes- A Short Course. 3rd Edition, Freeman and Co., USA.

**ELECTIVE GENERIC
BIOTECHNIQUES
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 25

- Unit 1: Assays: Definition and criteria of reliability; Chemical assays; Biological assays: *in vivo* and *in vitro* assays; Principles and uses of analytical instruments: Balances, pH meter, calorimeter, spectrophotometer, centrifuge and ultracentrifuge.
- Unit 2: Microscopy: Principle of light transmission, electron, phase-contrast, fluorescence, electron, confocal, scanning electron microscopes; Microphotography: Image analysers; Microbiological techniques: Media preparation and sterilization; Inoculation and growth monitoring; Use of fermenters and Microbial assays.
- Unit 3: Cell culture techniques: Design and functioning of tissue culture laboratory; Cell viability testing; Culture media preparation and cell harvesting methods; Separation techniques in biology: Molecular separations by chromatography, electrophoresis, precipitation etc.
- Unit 4: Computer aided techniques for data presentation, data analyses, statistical techniques, special software for specific tasks; Radioisotope and mass isotope techniques in biology: Autoradiography and Magnetic Resonance Imaging.
- Unit 5: Immunological techniques based on antigen-antibody interactions; Surgical techniques: Organ ablations (eg; ovariectomy, adrenaletomy etc.) and Perfusion techniques.

PRACTICAL

Marks 25

1. Measurement of pH of various substances.
2. Operation of monopan balance.
3. Use of simple and compound microscope.
4. Culture of plant cell and animal cells.
5. Chromatography.
6. Electrophoresis.
7. Preparation of culture media.
8. Measurement through micrometer.
9. Camera lucida drawing.
10. Determination of blood group through antigen antibody reaction.

SUGGESTED READING

1. Boyer R (2000) Modern Experimental Biochemistry. 3rd Edition. Addison Wesley Longman, Inc., USA.
2. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
3. Wilson K and Walker J (2010) Principles and techniques of Biochemistry and Molecular Biology. 7th Edition. Cambridge University Press, UK.

**ELECTIVE GENERIC
BIO INSTRUMENTATION
(CREDITS: THEORY-4, PRACTICALS-2)**

**THEORY
LECTURES: 60**

Marks 75

Unit 1: Units of measurements – Metric system, conversion of Units, Microscopy – principles & types (simple, light, phase contrast, polarizing darkfield& Electron) Autoclave – principle & applications and types.

Unit 2: Centrifuge: principles & types (clinical, ultra centrifuges); pH: Sorenson’s pH scale, pH meter: principle and applications; Manometry: Warburg manometer: principle and working.

Unit 3: Chromatography: Principles, types (paper, Thin layer, column) and applications; Electrophoresis: Principles, types-paper & gel (AGE & PAGE) and applications.

Unit 4: Spectroscopy: principles and uses of colorimetry and NMR (Nuclear Magnetic Resonance) spectroscopy; Radio isotopic technique: Radio immuno assay, Biochemical applications of radio isotopes.

Unit 5: Biosensors: principle, types (Enzyme, Bacterial electrodes, Environmental Bio sensors & Bioreporters & applications) DNA & RNA sequencing methods, PCR: principle & Application; DNA Micro array and its applications.

PRACTICAL

Marks 25

1. Analysis of glucose, amino acids / proteins fatty acids/ lipids and RNA/DNA in animal tissues by spectrophotometry.
2. Identification of amino acids by paper chromatography.
3. Demonstration of blotting techniques and PCR.
4. Sub-cellular fractionation by centrifugation.

SUGGESTED READINGS

1. Boyer R (2000) Modern Experimental Biochemistry. 3rd Edition. Addison Wesley Longman, Inc., USA.
2. Mohanty PK (2000) Illustrated Dictionary of Biology. Kalyani Publishers, Ludhiana.
3. Wilson K and Walker J (2010) Principles and techniques of Biochemistry and Molecular Biology. 7th Edition. Cambridge University Press, UK.