

CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMME

Under Graduate Syllabus

**Department of Zoology
Nagaland University
Lumami**

2023

**Approved by 36th Academic Council
(on 17th May, 2023)**

1. MINIMUM CREDIT REQUIREMENTS TO AWARD DEGREE UNDER EACH CATEGORY

Sl. No.	Broad Category of Course	Minimum Credit Requirement	
		3-year UG	4-year UG
1	Major (Core)	60	80
2	Minor Stream	24	32
3	Multidisciplinary	09	09
4	Ability Enhancement Courses (AEC)	08	08
5	Skill Enhancement Courses (SEC)	09	09
6	Value Added Courses common for all UG	08	08
7	Summer Internship	02	02
8	Research Project/ Dissertation	-	12
	Total Credits	120	160

2. SEMESTER-WISE AND BROAD COURSE CATEGORY- WISE DISTRIBUTION OF CREDITS

Semester	Major Courses	Minor Courses	Interdisciplinary/multidisciplinary courses	Ability Enhancement Courses	Skill Enhancement Courses/Internship/Dissertation	Common Value-Added Courses	Total Credits
I	C1 (4) C2 (4)	M1(4)	Env. Science (3)	Eng -1 (2)	SEC (3) Common Pool		20
II	C3 (4) C4 (4)	M2 (4)	Common Pool/Swayam (3)	MIL-1 (2)		Soft skill (3)	20
<i>Students exiting the programme after securing 40 credits will be awarded UG Certificate in the relevant Discipline/Subject provided they secure 4 credits in work based vocational courses offered during summer term or internship/Apprenticeship</i>							
III	C5 (4) C6 (4)	M3(4)	Understanding	Eng-2 (2)	SEC (3) Common Pool		20

			heritage/Com mon pool/ Swayam (3)				
IV	C7 (4) C8 (4)	M4 (4)		MIL-2 (2)	SEC (3) Common Pool	NCC/NSS /CP (3)	20
<i>Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline/Subject provided they secure additional 4 credit in skill based vocational courses offered during first year or second year summer term</i>							
V	C9 (4) C10 (4) C11 (4)	M5 (4)			Internship (2)	Work ethics (2)	20
VI	C12 (4) C13 (4) C14 (4) C15 (4)	M6 (4)					20
Total	60	24	9	8	11	8	120
<i>Students who want to undertake 3-year UG programme will be awarded UG Degree in the relevant Discipline/Subject upon securing 120 credits</i>							
VII	C16 (4) C17 (4) C18 (4) C19 (4)	M7 (4)			Research Dissertation starts		20
VIII	C20 (4)	M8 (4)			Research project/Dissert ation (12) OR C21 (4) C22 (4) C23 (4)		20

3. MAJOR COURSES (CORE PAPERS)

SEMESTER I

- C1 : Non-chordates I: Protista to Pseudocoelomates + Practical
C2 : Principles of Ecology + Practical

SEMESTER II

- C3 : Non-chordates II: Coelomates + Practical
C4 : Cell Biology + Practical

SEMESTER III

- C5 : Diversity of chordates + Practical
C6 : Physiology: Controlling and Coordinating systems + Practical

SEMESTER IV

- C7 : Fundamentals of Biochemistry + Practical
C8 : Comparative anatomy of vertebrates + Practical

SEMESTER V

- C9 : Physiology: Life Sustaining Systems + Practical
C10 : Biochemistry of Metabolic Processes + Practical
C11 : Molecular Biology + Practical

SEMESTER VI

- C12 : Principles of Genetics + Practical
C13 : Developmental Biology + Practical
C14 : Evolutionary Biology + Practical
C15 : Animal Behaviour and Chronobiology + Practical

SEMESTER VII

- C16 : Endocrinology + Practical
C17 : Immunology + Practical
C18 : Reproductive Biology + Practical
C19 : Research Methodology

SEMESTER VIII

C20 : LATER

C21 :-do-

C22 :-do-

C23 :-do-

5. SKILL ENHANCEMENT COURSE (SEC)

SEC : Aquarium Fish Keeping

SEC : Wild Life Conservation and Management

SEC : Food, nutrition and health

SEC : Medical Diagnostics

SEC : Apiculture

SEC : Sericulture

DETAILED SYLLABUS

C1 (T)

NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

THEORY

(Credits 3)

Unit 1:

Protista – general characteristics and classification up to classes.

Life cycle of *Euglena*, *Amoeba* and *Paramecium*.

Locomotion and reproduction in Protista.

Unit 2:

Symmetry and segmentation in Metazoa.

General characteristics of Porifera and classification up to classes.

Canal system and spicules in sponges.

Unit 3:

General characteristics of Cnidaria and classification up to classes.

Metagenesis in Obelia.

Polymorphism in Cnidaria.

Corals and Coral Reefs.

Unit 4:

Evolutionary significance of Ctenophora.

General characteristics of Platyhelminthes and classification up to classes.

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

Unit 5:

General characteristics of Nematelminthes and classification up to classes.

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

Parasitic adaptations in Helminthes.

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

C1 (P)

NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

PRACTICAL

(Credit 1)

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

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

SUGGESTED READINGS

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

C2 (T)
PRINCIPLES OF ECOLOGY

THEORY

(Credits 3)

Unit 1:

Ecology – autecology and synecology.
Levels of organization, Laws of limiting factors.
Ecology in wildlife conservation and management.

Unit 2:

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

Unit 3:

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

Unit 4:

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

Unit 5:

Types of ecosystems with one example in detail; Food chain – Detritus and Grazing food chains; Food web; Energy flow through the ecosystem; Ecological pyramids and Ecological efficiencies; Nitrogen cycle and Carbon cycle.

C2 (P)

PRINCIPLES OF ECOLOGY

PRACTICAL

(Credit 1)

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. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.

SUGGESTED READINGS

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

C3 (T)

NON-CHORDATES II: COELOMATES

THEORY

(Credits 3)

Unit 1:

Evolution and significance of coelom and metamerism.

General characteristics and evolutionary significance of Onychophora.

Unit 2:

General characteristics of Annelida and Classification up to classes.

Excretion, locomotion and economic importance of Annelida.

Unit 3:

General characteristics of Arthropoda and Classification up to classes.

Vision and Respiration in Arthropoda.

Metamorphosis and parthenogenesis in insects.

Unit 4:

General characteristics of Mollusca and Classification up to classes.

Torsion and detorsion in Gastropoda.

Pearl formation in bivalves.

Unit 5:

General characteristics of Echinodermata and Classification up to classes.

Water-vascular system in Asterozoa.

Larval forms in Echinodermata.

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

C3 (P)

NON-CHORDATES II: COELOMATES

PRACTICAL

(Credit 1)

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*
Echinoderms - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
2. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm.
3. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.
4. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta**.
5. To submit a Project Report on any related topic to larval forms (crustacean, mollusc and echinoderm).

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

SUGGESTED READINGS

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

C4 (T)
CELL BIOLOGY

THEORY

(Credits 3)

Unit 1:

Prokaryotic and Eukaryotic cells; Virus, Mycoplasma and Phages.

Various models of plasma membrane structure.

Transport across membranes – active and passive transport and facilitated transport.

Cell junctions – tight junctions, desmosomes and gap junctions.

Unit 2:

Structure and Functions – endoplasmic reticulum Golgi apparatus and lysosomes.

Transport systems involving endoplasmic reticulum, Golgi apparatus and lysosomes.

Unit 3:

Mitochondria – Structure, semi-autonomous nature, endosymbiotic hypothesis.

Mitochondrial respiratory chain; chemiosmotic hypothesis; Peroxisomes.

Unit 4:

Structure of nucleus – nuclear envelope, nuclear pore complex, nucleolus.

Chromatin – euchromatin and heterochromatin and packaging (nucleosome).

Unit 5:

Mitosis, meiosis, cell cycle and its regulation.

Structure and functions of microtubules, microfilaments and intermediate filaments.

C4 (P)
CELL BIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C5 (T)
DIVERSITY OF CHORDATA

THEORY

(Credits 3)

Unit 1:

General characteristics and outline classification of chordates.
General characteristics of Hemichordata, Urochordata and Cephalochordata.
Retgressive metamorphosis in Urochordata.

Unit 2:

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

Unit 3:

General characteristics and classification up to order of Chondrichthyes and Osteichthyes.
Migration, Osmoregulation and Parental care in fishes.
General characteristics of Amphibia and classification up to order.
Parental care in Amphibians.

Unit 4:

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

Unit 5:

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

C5 (P)

DIVERSITY OF CHORDATA

PRACTICAL

(Credit 1)

1. **Protochordata:** *Balanoglossus*, *Herdmania*, *Branchiostoma*, Colonial Urochordata
Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules.
2. **Agnatha:** *Petromyzon*, *Myxine*.
3. **Fishes:** *Scoliodon*, *Sphyrna*, *Pristis*, *Torpedo*, *Chimaera*, *Mystus*, *Heteropneustes*, *Labeo*, *Exocoetus*, *Echeneis*, *Anguilla*, *Hippocampus*, *Tetrodon/ Diodon*, *Anabas*, Flat fish.
4. **Amphibia:** *Ichthyophis/Ureotyphlus*, *Necturus*, *Bufo*, *Hyla*, *Alytes*, *Salamandra*.
5. **Reptilia:** *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Ophiosaurus*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis*, *Crocodylus*.
Key for Identification of poisonous and non-poisonous snakes
6. **Aves:** Study of six common birds from different orders. Types of beaks and claws.
7. **Mammalia:** *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceous*. Mount of weberian ossicles of *Mystus*, pecten from Fowl head. Dissection of Fowl head (Dissections and mounts subject to permission).
Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission)

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

SUGGESTED READINGS

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

C6 (T)

ANIMAL PHYSIOLOGY I: CONTROLLING AND COORDINATING SYSTEMS

THEORY

(Credits 3)

Unit 1:

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

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Hormonal control of testicular function; endocrine function of testis, young oocyte; mature graffian follicle.

Unit 5:

Endocrine glands in vertebrates; structures of cells and types.

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

C6 (P)

ANIMAL PHYSIOLOGY I: CONTROLLING AND COORDINATING SYSTEMS

PRACTICAL

(Credit 1)

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

(*Subject to UGC guidelines)

SUGGESTED BOOKS

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

C7 (T)

FUNDAMENTALS OF BIOCHEMISTRY

THEORY

(Credits 3)

Unit 1:

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

Unit 2:

Lipid classification; Structure, properties and biological significance of tri-acylglycerols, phospholipids, glycolipids and steroids.

Unit 3:

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

Unit 4:

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

Unit 5:

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

C7 (P)

FUNDAMENTALS OF BIOCHEMISTRY

PRACTICAL

(Credit 1)

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

SUGGESTED READING

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

C8 (T)
COMPARATIVE ANATOMY OF VERTEBRATES

THEORY

(Credits 3)

Unit 1:

Integumentary System: structure, functions and derivatives of integument.
Skeletal System – axial and appendicular skeleton of amphibian and reptile.

Unit 2:

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

Unit 3:

Digestive System: alimentary canal and associated glands, dentition.

Unit 4:

Circulatory System: general plan of circulation, evolution of heart and aortic arches;
Urinogenital System: succession of kidney; evolution of urinogenital ducts.

Unit 5:

Nervous System: comparative account of brain and spinal cord of mammals and Aves.
Sense Organs: classification of receptors; brief account of visual and auditory receptors in man.

C8 (P)

COMPARATIVE ANATOMY OF VERTEBRATES

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C9 (T)

ANIMAL PHYSIOLOGY II: LIFE SUSTAINING SYSTEMS

THEORY

(Credits 3)

Unit 1:

Digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Enzymes in Gastrointestinal tract.

Unit 2:

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

Unit 3:

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

Unit 4:

Composition of blood and its functions; Haemostasis, blood clotting system, Blood groups: Rh factor, ABO and antigenic determinants.

Unit 5:

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

C9 (P)
ANIMAL PHYSIOLOGY II: LIFE SUSTAINING SYSTEMS

PRACTICAL

(Credit 1)

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

(*Subject to UGC guidelines)

SUGGESTED READINGS

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

C10 (T)

BIOCHEMISTRY OF METABOLIC PROCESSES

THEORY

(Credits 3)

Unit 1:

Catabolism vs anabolism, stages of catabolism; compartmentalization of metabolic pathways, shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; use of reducing equivalents and cofactors.

Unit 2:

Sequence of reactions and regulation in citric acid cycle, phosphate pentose pathway, glycogenolysis and glycogenesis. Malate-aspartate shuttle, glycerol phosphate shuttle and Cori cycle.

Unit 3:

β -oxidation of saturated fatty acids with even and odd number of carbon atoms; omega - oxidation biosynthesis of palmitic acid; ketogenesis.

Unit 4:

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

Unit 5:

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

C10 (P)

BIOCHEMISTRY OF METABOLIC PROCESS

PRACTICAL

(Credit 1)

1. Estimation of total protein in given solutions by Lowry's method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue.
3. To study the enzymatic activity of trypsin and lipase.
4. Study of biological oxidation (SDH) [goat liver].
5. To perform the Acid and alkaline phosphatase assay from serum/ tissue.
6. Dry Lab: to trace the labelled C atoms of acetyl-CoA till they evolve as CO₂ in the TCA cycle.

SUGGESTED READINGS

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

C11 (T)
MOLECULAR BIOLOGY

THEORY

(Credits 3)

Unit 1:

DNA as genetic material; Watson and Crick model of DNA.

Mechanism of DNA replication; semi-conservative, bidirectional and semi-discontinuous replication; RNA priming; replication of telomeres.

Unit 2:

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

Unit 3:

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

Unit 4:

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

Unit 5:

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

C11 (P)
MOLECULAR BIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C12 (T)
PRINCIPLES OF GENETICS

THEORY

(Credits 3)

Unit 1:

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

Unit 2:

Linkage and crossing over; cytological basis of crossing over; molecular mechanisms of crossing over; recombination frequency as a measure of linkage intensity; somatic cell hybridization.

Unit 3:

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

Unit 4:

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

Unit 5:

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

C12 (P)

PRINCIPLES OF GENETICS

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C13 (T)
DEVELOPMENTAL BIOLOGY

THEORY

(Credits 3)

Unit 1:

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

Unit 2:

Spermatogenesis, oogenesis; types of eggs, egg membranes; fertilization (External and Internal); planes and patterns of cleavage; fate maps (including Techniques); early development of frog and chick up to gastrulation.

Unit 3:

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

Unit 4:

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

Unit 5:

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

C13 (P)
DEVELOPMENTAL BIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C14 (T)
EVOLUTIONARY BIOLOGY

THEORY

(Credits 3)

Unit 1:

Origin of life; Lamarckism, Neo Lamarckism, Darwinism, Neo-Darwinism; Germplasm and mutation theory of organic evolution.

Unit 2:

Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Molecular universality of genetic code and protein synthesising machinery; three domains of life, neutral theory of molecular evolution.

Unit 3:

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); evolutionary forces upsetting H-W equilibrium; concept of fitness, selection coefficient, genetic load, types of selection, sexual selection. genetic drift - founder's effect, bottleneck phenomenon.

Unit 4:

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

Unit 5:

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

C14 (P)
EVOLUTIONARY BIOLOGY

PRACTICAL

(Credit 1)

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.

SUGGESTED READINGS

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

C15 (T)

ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

THEORY

(Credits 3)

Unit 1:

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

Methods and recording of a behaviour.

Unit 2:

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

Unit 3:

Social Behaviour: concept of society; communication and the senses; altruism; Sexual Behaviour: asymmetry of sex, sexual dimorphism, mate choice, intra-sexual selection (male rivalry), inter-sexual selection (female choice), sexual conflict in parental care.

Unit 4:

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

Unit 5:

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

Relevance of biological clocks; chronopharmacology, chronomedicine, chronotherapy.

C15 (P)

ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C16 (T)
ENDOCRINOLOGY

THEORY

(Credits 3)

Unit 1:

Classification, characteristics and transport of hormones; Neurosecretions and Neurohormones.

Unit 2:

Structure of hypothalamus, regulation of neuroendocrine glands.

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

Structure of pineal gland; secretions and their functions.

Unit 3:

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

Unit 4:

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

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

Unit 5:

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

C16 (P)
ENDOCRINOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C17 (T)
IMMUNOLOGY

THEORY

(Credits 3)

Unit 1:

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

Unit 2:

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

Unit 3:

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

Structure and functions of different classes of immunoglobulins; antigen-antibody interactions.

Unit 4:

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

Properties and functions of cytokines.

Components and pathways of complement activation.

Unit 5:

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

Immunoassays (ELISA and RIA).

Various types of vaccines.

C17 (P)

IMMUNOLOGY

PRACTICAL

(Credit 1)

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

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

SUGGESTED READINGS

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

C18 (T)

REPRODUCTIVE BIOLOGY

THEORY

(Credits 3)

Unit 1:

Gonadal hormones and mechanism of hormone action; steroids, glycoprotein hormones, and prostaglandins; regulation of gonadotrophin secretion in male and female.
Development and differentiation of gonads.

Unit 2:

Testis: cellular functions, germ cell and stem cell renewal; Spermatogenesis: hormonal regulation; androgen synthesis and metabolism; epididymal function and sperm maturation; accessory glands functions; sperm transportation in male tract.

Unit 3:

Ovary: folliculogenesis, ovulation, corpus luteum formation and regression; steroidogenesis and secretion of ovarian hormones; reproductive cycles (human) and their regulation; fertilization; hormonal control of implantation; hormonal regulation of gestation, foeto – maternal relationship; mechanism of parturition and its hormonal regulation; lactation and its regulation.

Unit 4:

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST.

Unit 5:

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

C18 (P)
REPRODUCTIVE BIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

C19 (T)
RESEARCH METHODOLOGY

(Credits 4)

Unit 1:

Meaning, objectives, motivation; research methods vs methodology.

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

Unit 2:

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

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

Unit 3:

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

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

Data presentation using digital technology.

Unit 4:

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

Unit 5:

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

SUGGESTED READINGS

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

The following courses will be updated after NEP for PG is out.

CC 20

CC 21

CC 22

CC 23

MINOR COURSES
M1 (T)
ANIMAL CELL BIOTECHNOLOGY)

THEORY

(Credits 3)

Unit 1:

Concept and Scope of biotechnology.

Outline process of genetic engineering and recombinant DNA technology; isolation of genes.

Concept of restriction and modification: restriction endonucleases, DNA modifying enzymes.

Unit 2:

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

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

Unit 3:

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

Agarose and polyacrylamide gel Electrophoresis; Southern, Northern and Western blotting,

DNA sequencing: Sanger method, polymerase chain reaction, DNA Fingerprinting and DNA microarrays.

Unit 4:

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

Unit 5:

Development of recombinant vaccines, hybridoma technology, gene therapy.

Production of recombinant proteins: insulin and growth hormones.

Bio safety - physical and biological containment.

M1 (P)
ANIMAL CELL BIOTECHNOLOGY

PRACTICAL

(Credit 1)

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.

SUGGESTED READINGS

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

M2 (T)
ANIMAL DIVERSITY

THEORY

(Credits 3)

Unit 1:

General characters of Protozoa; Life cycle of *Plasmodium*.

General characters and canal system in Porifera.

General characters of Cnidarians and polymorphism.

Unit 2:

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

General characters of Nemethehelminthes; parasitic adaptations.

General characters of Annelida; metamerism.

Unit 3:

General characters of arthropoda; social life in insects.

General characters of mollusca; pearl formation.

General characters of Echinodermata; water vascular system in starfish.

Unit 4:

Salient features of Protochordates.

Osmoregulation, migration of fishes.

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

Unit 5:

Origin of reptiles; terrestrial adaptations in reptiles.

The origin of birds; flight adaptations.

Early evolution of mammals; primates; dentition in mammals.

M2 (P)
ANIMAL DIVERSITY

PRACTICAL

(Credit 1)

1. Study of following specimens:

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

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

2. Study of following Permanent Slides: Cross section of Sycon, Sea anemone and *Ascaris* (male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.
3. Temporary mounts of:
- Septal & pharyngeal nephridia of earthworm.
 - Unstained mounts of Placoid, cycloid and ctenoid scales.
4. Dissections of:
- Digestive and nervous system of Cockroach.
 - Urinogenital system of Rat

SUGGESTED READINGS

- 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.

M3 (T)
AQUATIC BIOLOGY

THEORY

(Credits 3)

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Unit 5:

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

M3 (P)
AQUATIC BIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

M4 (T)
BIOLOGY OF INSECTA

THEORY

(Credits 3)

Unit 1:

General Features of Insects.

Distribution and Success of Insects on the Earth.

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

Unit 2:

External Features; head – eyes, types of antennae, types of mouth parts.

Thorax: types of wings, types of legs.

Abdominal appendages and genitalia.

Unit 3:

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

Growth and metamorphosis.

Unit 4:

Social organization and social behaviour (Hymenoptera and Isoptera).

Role of allelochemicals in host plant mediation.

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

Unit 5:

Insects as mechanical and biological vectors.

Houseflies and mosquitoes as important insect vectors.

M4 (P)
BIOLOGY OF INSECTA

PRACTICAL

(Credit 1)

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

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

SUGGESTED READINGS

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

M5 (T)
BASICS OF NEUROSCIENCE

THEORY

(Credits 3)

Unit 1:

Origins of Neuroscience; neuroanatomy, neurophysiology, and systems neurobiology. Introduction to the structure and function of the nervous system.

Unit 2:

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

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

Unit 3:

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

Unit 4:

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

Unit 5:

Principles of signal transduction and information processing in vertebrate CNS; Perception and behaviour of neural system; molecular basis of behaviour (learning and memory).

Parkinson's, Alzheimer's, psychological disorders.

M5 (P)
BASICS OF NEUROSCIENCE

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

M6 (T)
FISH AND FISHERIES

THEORY

(Credits 3)

Unit 1:

General description of fish; account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction.
Types of fins and their modifications; locomotion in fishes; types of Scales.

Unit 2:

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

Unit 3:

Inland fisheries, marine fisheries; Fishing crafts and Gears; depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Fisheries law and regulations.

Unit 4:

Sustainable aquaculture, extensive, semi-intensive and intensive culture of fish; pen and cage culture, polyculture, composite fish culture; induced breeding of fish; management of finfish hatcheries; role of water quality in aquaculture.

Unit 5:

Transgenic fish, Zebrafish as a model organism in research; cryopreservation of gametes in fishes.
Fish diseases: bacterial, viral and parasitic; preservation and processing of harvested fish; fishery by-products.

M6 (P)
FISH AND FISHERIES

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

M7 (T)
HUMAN PHYSIOLOGY

THEORY

(Credits 3)

Unit 1:

Structure and function of digestive glands; digestion and absorption of carbohydrates, fats and proteins; nervous and hormonal control of digestion.

Unit 2:

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

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

Unit 3:

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

Unit 4:

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

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

Unit 5:

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

Spermatogenesis and oogenesis; menstrual cycle.

M7 (P)
HUMAN PHYSIOLOGY

PRACTICAL

(Credit 1)

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

SUGGESTED READINGS

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

M8 (T)
PARASITOLOGY

THEORY

(Credits 3)

Unit 1:

Introduction to Parasites and Vectors.

Study of Morphology, Life Cycle, Pathogenicity and Prophylaxis of *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*.

Unit 2:

Study of Morphology, Life Cycle, Pathogenicity and Prophylaxis of *Fasciolopsis buski*, *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana*.

Unit 3:

Study of Morphology, Life Cycle, Pathogenicity and Prophylaxis of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*.

Unit 4:

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

Unit 5:

Account of parasitic vertebrates; Cookicutter Shark, Candiru, Hood Mockingbird and Vampire bat.

M8 (P)
PARASITOLOGY

PRACTICAL

(Credit 1)

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

Submission of a brief report on parasitic vertebrates

SUGGESTED READINGS

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