

**Model Curriculum for Three/Four Year Degree Course**  
**(With Multiple Entry /Exit Option)**  
**Based on NEP-2020**

# **Zoology**



**Odisha State Higher Education Council, Bhubaneswar**  
**Government of Odisha**

Semester	Subjects
<b>I</b>	Core I - Invertebrates: Protista to Echinodermata
	Core II- Diversity of Chordates: Protochordates to Mammalia
<b>II</b>	Core III- Microbiology
	Core IV - Cell Biology
<b>III</b>	Core V- Principles of Ecology
	Core VI- Physiology: Controlling and Coordinating systems
	Core VII- Fundamentals of Biochemistry
<b>IV</b>	Core VIII- Endocrinology & Reproductive Biology
	Core IX- Comparative Anatomy of Vertebrates
	Core X- Physiology: Life Sustaining Systems
<b>V</b>	Core XI- Biochemistry of Metabolic Processes
	Core XII- Principles of Genetics
	Core XIII- Molecular Biology
<b>VI</b>	Core XIV- Developmental Biology
	Core XV- Taxonomy and Evolutionary Biology
<b>VII</b>	Core XVI- Instrumentation and Techniques
	Core XVII- Biostatistics and Bioinformatics
	Core XVIII- Animal Biotechnology
	Core XIX- Immunology
<b>VIII</b>	Core XX- Aquatic Biology and Toxicology
	Core XXI- Wildlife and Conservation Biology
	Core XXII- Chronobiology & Animal Behaviour
	Core XXIII- Research Project

## Programme Outcomes

- To prepare the students for a career in Zoology.
- To prepare the students for Higher Education and Research in Zoology.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To generally promote wider reading on the subject and allied inter disciplinary subject.

## **Semester I**

### **Core I**

### **Invertebrates: Protista to Echinodermata**

**Programme Outcome:**

- Understand the general characteristics of non-chordate groups of organisms.
- Acquire knowledge regarding classification of the taxa with examples.
- Develop an understanding of important phenomena associated with each taxon.
- Acquire skills in identifying representative species of groups studied.
- Illustrate phylogenetic distribution of lower groups of Non-chordates.
- Understand elaboration of coelomic evolution and metamerism on Coelomates with their classification up to their class and excretion system in Annelidans.
- Recognize insect vision, respiration and metamorphosis in Arthropoda with reference to Termites and in evolutionary significance of Onychophora with general characteristics.
- Obtain an over view of the general features, respiration, Gastropodan evolution, mechanism of torsion, and significance of larval life stages.
- Acquire knowledge on general characters and classification of Echinoderms and their affinities with Chordates.

**Course Outcome:**

- Utilize information to understand the differences of the groups studied.
- Develop skills in examining diversity of the taxa.
- Develops skills in elaborating the general features and evolutionary significance of the coelomate from Annelida to Echinoderms.
- Impactful visual understanding and enables the students to correlate the evolutionary significance of each organism on the phylogenetic tree.
- Study on various general features and characteristics of body symmetry and arrangement with various vision types, excretory systems and developmental stage give a strong fundamental understanding on the subject on Coelomates.

**Learning Outcome**

- Systematically understand the diverse group of organisms from Protista to Cnidaria and Ctenophora
- Systematically understand the diverse group of organisms that make up Phyla Platyhelminthes and Nematelminthes.
- Understand the diverse organisms that make up Phyla from Annelida, Arthropoda and Onychophora.
- Understand the diverse organisms that make up Phyla from Mollusca and Echinodermata and significant processes associated.

**Unit 1: Protista to Cnidaria and Minor Phylum Ctenophora**

General characteristics and Classification up to classes. Locomotion, Nutrition and Reproduction in Protista, Life cycle and pathogenicity of *Plasmodium vivax*, Canal system

and spicules in sponges, Metagenesis in Obelia, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora.

### **Unit 2: Platyhelminthes and Nemathelminthes**

General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*, Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*. Parasitic adaptations in helminthes

### **Unit 3: Annelida, Arthropoda and Onychophora**

General characteristics and Classification up to classes. Evolution of coelom and metamerism. Excretion in Annelida, Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites. Onychophora: General characteristics and Evolutionary significance.

### **Unit 4: Mollusca and Echinodermata**

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Evolutionary significance of trochophore larva. Water-vascular system in Echinoderms, Larval forms in Echinodermata

### **TEXT BOOKS**

- ✓ Kotpal RL; *Modern Textbook of Zoology – Invertebrates*; Rastogi Publications - Meerut; 2016 edition.
- ✓ Richard Brusca, W. Moore, Stephen M. Shuster. *Invertebrates*; OUP USA; 3 edition (19 January 2016).

### **SUGGESTED READINGS**

- ✓ Richard Fox, Robert D. Barnes, Edward E. Ruppert, *Invertebrate Zoology: A Functional Evolutionary Approach*, Brooks/Cole; 7th edition edition 2003
- ✓ Barrington, E.J.W. *Invertebrate Structure and Functions. II Edition*, E.L.B.S. and Nelson.
- ✓ Hyman, L.H. *Invertebrate Series (Recent edition)*.
- ✓ Parker JJ and WA Haswel *Textbook of Zoology. Vol I and II*.
- ✓ Barrington, E.J.W. (1979). *Invertebrate Structure and Functions. II Edition*, E.L.B.S. and Nelson.
- ✓ 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.

## **Invertebrates: Protista to Echinodermata**

### **Practical**

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium*.
2. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongilla*, Spicules and Spongin fibers.
3. Study of Cnidarians *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora*., *Ctenophore*.
4. Study of Life cycle stages of *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides* (Slides/micro-photographs).
5. Study of Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*.
6. Study of Arthropods – Crab, *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx mori*, *Periplaneta americana*, termites, honey bees and *Peripatus*
7. Study of Molluscs and Echinodermata- *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*.  
Echinodermata - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
8. Study of digestive system, nephridia of earthworm (Virtual), T.S. through pharynx, gizzard, and typhlosolar region of earthworm, Mounting of mouth parts and dissection of digestive system and nervous system (Virtual) of *Periplaneta americana*.
9. To submit a Project Report on any related topic.

### **Suggested Reading**

- ✓ Verma PS and Srivastava PC. (2011) *Advanced Practical Zoology*. S Chand Publication.
- ✓ S.S Lal. (2019) *Practical Zoology (Invertebrate)* Rastogi Publications.

## **Core II      Diversity of Chordates: Protochordates to Mammalia**

### **Programme Outcome:**

- The students learn about the salient features, diversity and distribution of all Chordates.
- To know the evolution of aquatic, amphibious and terrestrial vertebrates.
- To understand the importance of distribution of vertebrates in different realms.

#### **Course Outcome:**

- Understanding the origin, larval forms, distribution and adaptation of different vertebrates.
- Accumulating the knowledge and understanding on the classification, affinities and comparative anatomy of different vertebrates and their evolutionary significance.
- Learning the mechanism of flight and aquatic adaptations in birds and mammals.
- Obtaining knowledge pertaining to the distribution of animals particularly vertebrate in different realms.

#### **Learning Outcome:**

- Gain understanding of Protochordates and origin of Chordates.
- Knowledge regarding characteristics and classification of Agnatha, Pisces, Amphibia, and evolution of tetrapoda.
- Understanding characteristics and classification of Reptiles and Aves and their connecting links.
- Comprehend characteristics and organization of mammals, in addition to their distribution in zoogeographical realms.

### **Unit 1: Protochordates and Origin of Chordates**

General characteristics and outline classification Chordata (Protochordata: Hemichordata, Urochordata and Cephalochordata). Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordat; Dipleurula concept and the Echinoderm theory of origin of chordates.

### **Unit 2: Agnatha, Pisces & Amphibia**

General characteristics and classification up to order. Migration, Parental care in fishes, Accessory respiratory organs in Pisces, Evolutionary significance of Dipnoi. Amphibia: Origin of Tetrapoda (Evolution of terrestrial ectotherms); Parental care.

### **Unit 3: Reptilia & Aves**

General characteristics 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 4: Mammals & Zoogeography**

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

pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

### PRACTICAL

1. Protochordata: *Balanoglossus*, *Herdmania*, *Branchiostoma*, Urochordata, Sections of *Balanoglossus* through proboscis and branchio-genital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slides of *Herdmania* spicules, *Doliolum*, *Salpa*
2. Agnatha: *Petromyzon* and *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*, Salamander.
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. Study of feathers.
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceus*.
8. Power point presentation on study of any two examples representing two different classes.. Submission of report on local species.

### Text Books:

- ✓ *Kotpal RL; Modern Textbook of Zoology –Vertebrates; Rastogi Publications - Meerut; 2016 edition*
- ✓ *Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.*
- ✓ *Tiwari SK (2006) Fundamentals of World Zoogeography, Sarup & Sons.*

### Suggested Readings:

- ✓ *Pough H. Vertebrate life, VIII Edition, 2007 Pearson International.*
- ✓ *Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.*
- ✓ *Hickman CP, Roberts LS, Keen S, Larson A, I'AnsonH, Isenhour DJ Integrated Principle of Zoology, 14th edition, 2008, McGrawHill publication.*



**Core III**

**Semester II**  
**Microbiology**

**Programme Outcome:**

- Knowledge of microbial diversity and classification.
- To understand microbial culture, growth and reproduction.
- To understand the importance of viral pathogenicity, nature of viral transmission.
- To comprehend the importance of Anti-viral drugs and vaccines.

**Course Outcome:**

- Obtaining knowledge pertaining to future scopes and modern trends of microbiology.
- Understanding the experimental approaches to explore the origin of microbes.
- Understanding the morphology, classification and significance of host-vector relationship.
- Learning the mechanism of action of microbial toxins and pathogenicity.
- Obtaining knowledge on pathogenic manifestation of Oncoviruses & HIV.

**Learning Outcome:**

- Finding the historical background and modern experimental approaches to understand the origin and development of microbiology.
- Analysing the general features, classification and pathogenicity of Archea and Eubacteria.
- Deducing knowledge on role of microbes in agriculture and healthcare sector.
- Interpreting the mechanism of antibacterial and anti-viral their mode of action, and importance of vaccines.

**Unit-1**

**History and development of microbiology:** Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming's experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

**Unit-2**

**Microbial systems of classification:** General features of Bergey's manual for classification of microbes, Whittaker's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition and Reproduction.

General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

**Unit-3**

**Isolation, culture and maintenance of microorganisms:** Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

**Unit-4**

**Virion and viroids:** General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

### **PRACTICAL**

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

### **Core-IV**

### **Cell Biology**

#### **Programme Outcome:**

- Introducing prokaryotic and eukaryotic cells and their features, ultrastructure of plasma membrane and mechanism of transport of molecules across plasma membrane.
- To know the structure, function and properties of endomembrane & cytoskeletal network system and cell organelles.
- To understand the importance of mitochondria in aerobes, the role of mitochondrial electron transport chain, oxidative phosphorylation & mechanism of ATP synthesis.
- To study the structure and packaging of chromosome in nucleus, behaviour of chromosome during cell division, cell cycle and its regulation.

### **Course Outcome:**

- Understanding the difference between prokaryotic and eukaryotic cells and the mechanism of transportation across their membrane system.
- Understanding the role of cytoskeleton in maintaining structural frame work, cell motility and cell organelles.
- Deciphering the role of mitochondria in cellular respiration and energy production.
- Obtaining knowledge on structure and function of nucleus, cell division and regulation of cell cycle.

### **Learning Outcome**

Understanding Cell junctions and mechanism of transportation across membrane.

- Obtaining knowledge on structural and functional aspect of cytoskeleton and endomembrane system.
- Obtaining knowledge on nucleus, nucleosome and cell division and cell cycle regulation.
- Knowledge about mitochondrial respiratory chain, chemi-osmotic hypothesis and functions of peroxisome.

### **Unit 1: Overview of cells and plasma membrane**

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure. Transport across membranes: Active and Passive transport, Facilitated transport. Cell junctions: Tight junctions, Desmosomes, Gap junctions.

### **Unit 2: Cytoskeleton & Endomembrane System**

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments;

Structure and Functions: Endoplasmic Reticulum, Golgi apparatus, Lysosomes.

### **Unit 3: Mitochondria and Peroxisomes**

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis; Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis. Peroxisomes.

### **Unit 4: Nucleus, Cell Division and Cell signalling**

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus; Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome); Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP).

#### **Text Books:**

- ✓ 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.*

#### **Suggested Readings:**

- ✓ 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.*
- ✓ 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.*
- ✓ Suvarna S, Lyton C, Bancroft JD (2013) *Theory and practice of histological techniques, Churchill Livingstone, Elsevier, UK*
- ✓ 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.*

### **PRACTICAL**

1. Understanding of simple and compound microscopes.
2. To study different cell types such as buccal epithelial cells, striated muscle cells using Methylene blue/any suitable stain (virtual/ slide/slaughtered tissue).
3. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
4. Study of various stages of meiosis in grasshopper testis
5. Preparation of permanent slide to show the presence of Barr body in human

female blood cells/cheek cells.

6. Preparation of permanent slide to demonstrate:
  - i. DNA by Feulgen reaction
  - ii. DNA and RNA by MGP
  - iii. Mucopolysaccharides by PAS reaction
  - iv. Proteins by Mercuric bromophenol blue/Fast Green
7. Demonstration of osmosis (RBC/ Egg etc.).

**Suggested Reading:**

1. Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. S Chand Publication.
2. S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.

**Semester-III**

**Core-V**

**Principles of Ecology**

**Programme Outcome:**

- Understand the concept of an ecosystem, its attributes, factors and functioning.
- Learn about population attributes, growth patterns, strategies; regulation and interactions.
- To appraise learners regarding various community characteristics.
- Comprehend biological data, learn graphical representation of data, sampling techniques, grasp basic statistics.
- Acquire skills on plotting survivorship curves, quadrat method of determining population density, diversity indices, techniques of preservation and mounting of plankton, determination of ecological parameters.

#### **Course Outcome:**

- Utilize information to understand interrelations and working of an ecosystem.
- Demonstrate the ability to comprehend data, plot graphs, present data and apply basic statistics.

#### **Learning Outcome:**

- Understand food chain dynamics and energy flow patterns.
- Gain knowledge about population dynamics.
- Understand community stratification and succession.
- Gain knowledge about representation of data, data processing and analysis.

### **Unit 1: Ecosystem and Applied Ecology**

Ecology: Autecology and synecology, Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Laws of limiting factors, Study of physical factors- (Light, temperature).

### **Unit 2: Population**

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.

### **Unit 3: Community**

Community characteristics: species richness, dominance, diversity, abundance, vertical

stratification, Ecotone and edge effect; Ecological succession with one example. Theories pertaining to climax community.

#### **Unit – 4: Biometry**

Biological data, graphical representation of data (frequency polygon and histogram), sampling techniques, measures of central tendency (Mean, median and mode), Measures of dispersion (range, quartile deviation, mean deviation and standard deviation), Hypothesis and hypothesis testing (Chi-square test, t- test).

#### **Text Book:**

- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5<sup>th</sup> Edition*
- ✓ *Smith and Smith, Elements of Ecology, Global Edition; Pearson Education India; ninth edition (14 May 2015).*
- ✓ *Myra Samuels, J. Witmer, A. Schaffner, Statistics for the life sciences, Prentice Halls, Boston, 4<sup>th</sup> edition, 2012.*

#### **Suggested Readings:**

- ✓ *Kormondy, (2017). Concepts of Ecology, Updated 4/e, Pearson.*
- ✓ *Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.*
- ✓ *Ricklefs, R.E., (2000). Ecology. 5<sup>th</sup> Edition. Chiron Press.*
- ✓ *Dash M.C., Fundamentals of Ecology. Mc GrawHill*
- ✓ *Smith TM and Smith RL, Elements of Ecology, 8th Edition, Pearson education INC, USA*
- ✓ *Miller, G.T. and Spoolman, S.E. (2017) Environmental Science, 14<sup>th</sup> Edition. Cengage Publication, New Delhi.*
- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5<sup>th</sup> Edition.*
- ✓ *Cengage Publication, New Delhi*
- ✓ *Web site: <https://www.cbd.int/>*
- ✓ *Baneerjee Pranab Kumar, Introduction to biostatistics, S Chand & Company; 3rd Rev. Edn. 2006 edition*
- ✓ *Chainy GBN, Mishra G, MohantyPK, 2004, Basic Biostatistics, Kalyani Publisher.*

#### **PRACTICAL**

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 collection, preservation and mounting, Measurement of temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), BOD, COD, Free CO<sub>2</sub>, Hardness, TDS.
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.
5. Chi-square analysis using seeds/beads/Drosophila.
6. Problems on standard deviation.
7. Graphical representation of data (Frequency polygon and Histogram).

**Suggested Reading:**

- ✓ *Practical Ecology by David Slingsby, Ceridwen Cook, Red Globe Press London.*
- ✓ *Practical Methods in Ecology by Henderson Peter A. John Wiley and Sons Ltd.*
- ✓ *Practical Ecology by Rao K S, K.S. Rao. Anmol Publications.*

**Core-VI                      Physiology: Controlling and Coordinating systems**

**Programme Outcome:**

- Develop an understanding of tissues and tissue systems with clarity on types and functions of each.
- Acquire knowledge on the muscle and nervous system.
- Obtain information about various receptors, their functioning and understand the mechanism of action.

#### **Course Outcome:**

- Acquire skills in differentiating tissues based on their structure and functions.
- Gain insights on the controlling and coordinating systems of the body.

#### **Learning Outcome:**

- Gain knowledge about tissue composition and function.
- Understand muscle types and mechanism of action.
- Understand functioning of different type of receptors.
- Acquire knowledge on osmoregulation and thermoregulation.

#### **Unit 1: Tissues & Tissue system**

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: Muscle & Nervous System**

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction. Introduction to CNS, PNS and ANS. Structure of neuron, Types of neurons, Action potential and its propagation, Synapse and synaptic transmission, Neuromuscular junction; Reflex action.

#### **Unit 3: Physiology of Special senses**

Sensory Neurons-types; Physiology and pathway- hearing and balance, Olfaction, Gustation and Vision. Interoception – Nociceptors, Baroreceptors, Chemoreceptors, Thermoreceptors, Osmoreceptors, Cutaneous Receptors.

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

Homeostasis and body fluids, Sources of body water and loss, Control of homeostasis, Homeostatic imbalances. Osmoregulation in fish, thermoregulation in Poikilotherms, homeotherms and heterotherms.

**Text Books:**

- ✓ *Marieb EN and Hoehn K, Human Physiology, (2013), 9th edition, Pearson Education, USA.*
- ✓ *Endocrinology, Hadley ME and Levine JE (2009), Pearson Education India; 6 edition.*
- ✓ *Textbook of Medical Physiology, Guyton & Hall, Elsevier, 12<sup>th</sup> edition, 2016.*

**Suggested Books:**

- ✓ *Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition., Lippincott W. & Wilkins*
- ✓ *Martini F H, Nath J L and Bartholomew E F (2015) Fundamentals of Anatomy and Physiology. Pearson Education Publication,*
- ✓ *Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B.Saunders Company.*
- ✓ *Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.*

**Practical****Physiology: Controlling and Coordinating systems**

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex).
2. Study of permanent slides- Squamous epithelium, Striated muscle fibres, nerve cells and others relevant to the theory.
3. Microtomy: Preparation of permanent slides.
4. Models of mammalian tissues (Any five) /photographs.
5. Effect of salt concentration on cells.

**Programme Outcome:**

- To gain understanding of fundamentals of biochemistry and biological macromolecules.
- To understand structure, classification, properties and significance of biomolecules.
- Acquire knowledge on nomenclature, classification and mechanism of enzyme action, regulation and its kinetics.

**Course Outcome:**

- To understand the structure and biological importance of protein, carbohydrates, lipids, nucleic acids and enzymes.
- Providing knowledge on types of amino acids and its polymeric form.
- Learning the structure and pairing of nucleotides, denaturation and denaturation kinetics of DNA.
- Obtaining knowledge on enzymes and isoenzymes, specificity, inhibition, derivation of Michaelis-Menten equation.

**Learning Outcome:**

- Gaining knowledge on different classes of biological macromolecules such as carbohydrates, lipids and nucleic acids.
- Understanding the structure of proteins and its monomers.
- Learning the structure of nucleic acids, denaturation and renaturation kinetics of DNA.
- Interpret the activities of enzymes and isoenzymes.

**Unit 1: Carbohydrates & Lipids**

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

**Unit 2: Proteins**

Amino acids: Structure, Classification and General properties of  $\alpha$ -amino acids; Physiological importance of essential and non-essential  $\alpha$ -amino acids.

Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Renaturation, Denaturation; Introduction to simple and conjugate proteins

Immunoglobulins: Basic Structure, Classes and Function, Antigenic Determinants.

**Unit 3: Nucleic Acids**

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

**Unit 4: Enzymes**

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, Multi-substrate reactions, Enzyme inhibition, Allosteric enzymes and their kinetics, Regulation of enzyme action.

#### **Text Books:**

- ✓ *Satyanarayan and Chakrapani, (2017) Biochemistry, Elsevier; Fifth edition*
- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.*
- ✓ *Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto, Biochemistry, 8<sup>th</sup> edition, 2015.*
- ✓ *Victor W., Rodwell, David A., Bender, Kathleen M., Botham, Peter J., Kennelly, P. Anthony, Harper's Illustrated Biochemistry, 31<sup>st</sup> edition.*

#### **Suggested Readings:**

- ✓ *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.*
- ✓ *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 Publication.*
- ✓ *Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.*
- ✓ *Devasena T. (2010). Enzymology Oxford University Press; 1 edition*
- ✓ *Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.*

### **Fundamentals of Biochemistry**

#### **Practical:**

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/Urease/acid or alkaline phosphatase
5. Demonstration of proteins separation by SDS-PAGE.

## **Semester-IV**

## **Core VIII**

## **Endocrinology & Reproductive Biology**

### **Programme Outcome:**

- Insights on the history of endocrinology, study endocrine glands, hormones, control and regulation
- Acquire knowledge on the various facets of the reproductive system and their endocrine aspects.

### **Course Outcome:**

- Essential clarity on endocrine gland structures, hormones, functions and their regulation.
- Scientific knowledge base on reproductive health and endocrine control.

### **Learning Outcome:**

- Acquire information on the history of endocrinology, endocrine glands, and hormones.
- Gain an understanding of the Hypothalamo-hypophyseal axis and regulation of hormone action.
- Understand the endocrine aspects of reproductive system.
- Recognize different aspects of reproductive health and Assisted Reproductive Technology.

### **Unit 1: Introduction to Endocrinology**

A brief history of endocrinology, Types of endocrine glands (Pituitary, Pineal, Thyroid, Parathyroid, Adrenal, Pancreas), their histology, hormones, functions and disorders; General characteristics of Hormones, Classification, Hormone receptors, Mechanism of hormone action (steroidal and non-steroidal hormones) and transduction.

### **Unit 2: Hypothalamo-hypophyseal Axis and Regulation of Hormone Action**

Structure of hypothalamus, Hypothalamic nuclei, Neurosecretions, Neurohormones and their functions, Hypothalamo-hypophyseal portal system, Hypothalamic-pituitary-gonadal axis,

Hormone action at cellular and molecular level, Genetic control of hormone action. Regulation-Feedback mechanisms.

### **Unit 3: Reproductive System-endocrine aspects**

Testis: Histology; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Sperm transportation in male tract; Ovary: Histology, folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles and their regulation, Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization, prevention of polyspermy; Hormonal control-implantation and gestation, foeto-maternal relationship; Parturition and Lactation.

### **Unit 4: Reproductive Health**

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

#### **Text Books:**

- ✓ *C. Donnell Turner (2012) General Endocrinology Pub- Affiliated East-West press Pvt. Ltd.-New Delhi; 6th Edition*
- ✓ *Hadley, M.E. and Levine J.E. (2007). Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey*
- ✓ *Austin, C.R. and Short, R.V. (1982) Reproduction in Mammals. Cambridge University Press.*
- ✓ *C. Donnell Turner (2012) General Endocrinology Pub- Affiliated East-West press Pvt. Ltd.-New Delhi; 6th Edition*
- ✓ *Tandulwadkar Sunita R (2015) The Art & Science Of Assisted Reproductive Technology, Jaypee Brothers Medical Publishers*

#### **Suggested Readings:**

- ✓ *Stephen Nussey and Saffron Whitehead (2001). Endocrinology: An Integrated Approach; Oxford: BIOS Scientific Publishers*
- ✓ *Tony M. Plant and Anthony J. Zeleznik (2015) Knobil and Neill's Physiology of Reproduction, Academic Press*

### **Endocrinology & Reproductive Biology**

#### **Practical:**

1. Dissect and display of Endocrine glands in laboratory bred rat\*.
2. Study of the permanent slides of all the endocrine glands.
3. Study and identification of endocrine disorders through images.
4. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat\*.
5. Demonstration of Castration/ ovariectomy in laboratory bred rat\*.
6. Estimation of plasma level of any hormone using ELISA.
7. Designing of primers of any hormone.
8. Examination of vaginal smear from live animals and examination of Human vaginal exfoliate cytology.
9. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats. (\*Subject to UGC guidelines)
10. Sperm count and sperm motility in rat.



11. Study of modern contraceptive devices.
12. Report on endocrine disorders in human.
13. Paper chromatographic separation of hormones.
14. Hypophysectomy in fish (Tilapia/catfish/ locally available fish)

**Programme Outcome:**

- Understand anatomical significance of organ system in vertebrates.
- Comprehend structure, function and various derivatives of Integumentary, Skeletal, digestive, respiratory, circulatory, urinogenital and nervous system.

**Course Outcome:**

- Learner gains detailed overview of the anatomical resemblance amongst vertebrates hierarchies.
- Acquires knowledge on cellular development of organ systems in the vertebrates and linear progression of cellular derivatives during organogenesis.
- Understand the process of linear and vertical cellular evolutionary processes.

**Learning Outcome:**

- Acquire knowledge of the integument, and skeleton systems.
- Gain knowledge on the Gastro intestinal canal, associated glands, and respiration system.
- Obtain knowledge of the Circulatory and Urinogenital systems and their evolution.
- Comparative study of mammalian nervous system & sense organs.

**Unit 1: Integumentary & Skeletal System**

Structure, functions and derivatives of integument (Scale, claw, nail, hair, feather and dentition). Axial and appendicular skeleton, Jaw suspensorium, Visceral arches.

**Unit 2: Digestive & Respiratory System**

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

**Unit 3: Circulatory and Urinogenital system**

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

**Unit 4: Nervous System & Sense Organs**

Comparative account of brain; Nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors: Brief account of visual and auditory receptors in man. Chemo and mechano-receptors

**Practical**

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 (Photographs, charts etc).
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) through ICT tools.
6. Project report submission on Integumentary derivatives.

**Text Books:**

- ✓ 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
- ✓ R. K. Saxena and Sumitra Saxena (2016). Comparative Anatomy of Vertebrates 2nd edition.

**Suggested Readings:**

- ✓ Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate tructure*, John Wiley and Sons
- ✓ Walter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House

**Programme Outcome:**

- Knowledge of critical physiological processes.
- Understand anatomical attributes of Digestive, Respiratory, Renal and Cardiovascular system.
- Learn and develop an understanding of vital life-sustaining physiological processes.

**Course Outcome:**

- Appraise the significance of anatomical structures and physiological events.
- Apply information to understand the functioning of organisms.
- Demonstrate the ability to appreciate the occurrence of physiological actions.
- Understand interrelationships of life processes.
- Acquire practical skills in identifying different organs, and perform laboratory work based on theoretical applications

**Learning Outcome:**

- Acquire knowledge on digestion, respiration, renal and heart physiology.
- Understand the composition of blood grouping, functions and Blood clotting.

**Unit 1: Physiology of Digestion**

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

**Unit 2: Physiology of Respiration**

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

**Unit 3: Renal Physiology**

Structure of kidney and its functional unit, Mechanism of urine formation, Regulation of water balance, Regulation of acid-base balance, Homeostatic regulation of tubular reabsorption and secretion.

**Unit 4: Blood and Physiology of Heart**

Haemopoiesis, Components of blood and their functions; Structure and functions of haemoglobin, Blood clotting system, Blood groups: Rh factor, ABO and MN.

Structure of mammalian heart, Coronary circulation, Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure.

**Practical:**

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

**Text Books:**

- ✓ Marieb E.N. and Hoehn K.N. (2009) Human Physiology. Pearson Education Publication , 9<sup>th</sup> edition
- ✓ Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.
- ✓ Guyton & Hall, (2016) Textbook of Medical Physiology. Elsevier, 12<sup>th</sup> edition.

**Suggested Readings:**

- ✓ 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.
- ✓ Moyes C.D., Schulte PM (2016), Principles of physiology, 2nd edition, Pearson education, 3rd.
- ✓ Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.

**Semester-V**

## Core XI

## Biochemistry of Metabolic Processes

### Programme Outcome

- Understanding of catabolism, anabolism and regulatory mechanism of intermediary metabolism.
- To learn the processes of carbohydrate, lipid and protein metabolism.
- To obtain knowledge on redox regulation and electron transport system.

### Course Outcome:

- Gain overall knowledge and understanding on metabolic pathways and shuttle systems.
- Gain knowledge on carbohydrate metabolism related processes.
- Understanding of  $\beta$ -oxidation and catabolism of amino acids.
- Understanding on mitochondrial respiratory chain and oxidative phosphorylation.

### Learning Outcome:

- Gain knowledge on the compartmentalization of metabolic pathways.
- Understand role of intermediate and carbohydrate regulatory metabolism.
- Gain knowledge on  $\beta$  and omega oxidation of saturated fatty acids.
- Understand the role of mitochondria in energy production during electron transport.

### Unit 1: Overview of Metabolism

Catabolism vs Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

### Unit 2: Carbohydrate Metabolism

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

### Unit 3: Lipid and protein Metabolism

B-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis

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

### Unit 4: Oxidative Phosphorylation

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

## Practical

1. Estimation of total protein in given solutions
2. Measurement of SGOT and SGPT activity.
3. Determination of GSH level in serum/tissue.
4. Measurement of GST activity.
5. To study the enzymatic activity of Trypsin/ Lipase.
6. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
7. Dry Lab (Virtual): To trace the labelled C atoms of Acetyl-CoA till they evolve as CO<sub>2</sub> in the TCA cycle.

**Text Books:**

- ✓ *Satyanarayan and Chakrapani, (2017) Biochemistry, Elsevier; Fifth edition.*
- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.*

**Suggested Readings:**

- ✓ 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.
- ✓ Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- ✓ Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

**Programme Outcome:**

- Obtain knowledge on the basic principles of genetics.
- To provide knowledge on the mechanism of sex determination and extra-chromosomal inheritance.
- To learn the process of DNA recombination, transposons and transposable elements.

**Course Outcome:**

- Acquire knowledge on the fundamentals of Mendelian and non-Mendelian genetics, chromosomal mapping and interaction of genes.
- Providing the knowledge and understanding on linkage, crossing over, sex determination and role of extra-chromosomal inheritance.
- Obtaining knowledge on chromosomal aberration, cause and consequences of mutations.

**Learning Outcome:**

- Understand principles of Mendelian genetics.
- Discern types of gene mutations and chromosomal aberrations with detection methods..
- Gain an understanding of mechanisms of sex determination and extra chromosomal inheritance.
- Understand the process of recombination and transposable genetic elements.

**Unit 1: Mendelian Genetics, Linkage, Crossing Over and Chromosomal Mapping**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance. Polygenic inheritance with suitable examples; simple numerical based on it.

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

**Unit 2: Mutations**

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB and sex-linked visible attached X method.

**Unit 3: Sex Determination & Extra-chromosomal Inheritance**



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

#### **Unit 4: Recombination in Bacteria and Viruses & Transposable Genetic Elements**

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in human.

#### **Practical**

1. Study of Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Experiments on epistatic interactions including test cross and back cross.
7. Experiments on probability and Chi-square test.
8. Study on sex linked inheritance in *Drosophila*.

#### **Text Books:**

- ✓ *Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freeman publication*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition.*

#### **Suggested Readings:**

- ✓ *Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition.*
- ✓ *Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.*
- ✓ *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.*

**Programme Outcome:**

- Detailed information on DNA structure, different forms, their properties and types of RNA.
- Understanding mechanism of DNA replication and repair in prokaryotes and eukaryotes.
- Gain knowledge on mechanism of transcription and translation in prokaryotic and eukaryotic cells.
- Acquire knowledge on post transcriptional modifications of RNA.

**Course Outcome:**

- Gain knowledge on details of Watson-Crick Model of DNA, RNA types .
- Understand the process of DNA replication, transcription, translation and their regulatory mechanisms.
- Gain knowledge on genetic code & regulatory machinery.
- Understand gene expression and role of RNA interference elements.

**Learning Outcome:**

- Gain knowledge on the fundamentals of double helical structure of DNA, denaturation and renaturation kinetics DNA, mechanism of replication and repair of DNA.
- Acquire knowledge on process of transcription, translation and post-processing regulatory mechanisms.
- Obtain knowledge on splicing mechanism, RNA editing, Processing of rRNA and tRNA.
- Understand operon concept and regulation.

**Unit 1: Nucleic Acids, DNA Replication & Repair**

Salient features of DNA: Watson and Crick model of DNA, DNA denaturation and renaturation kinetics, Cot curves, C-value paradox, Salient features of RNA

DNA Replication in prokaryotes and eukaryotes: Semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear ds-DNA and RNA priming, replication of telomeres.

DNA repair mechanism: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.

**Unit 2: Transcription & Translation**

Transcription: RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors and regulation of transcription.

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 synthetase 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 3: Post Transcriptional Modifications and Processing of Eukaryotic RNA**

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

### **Unit 4: Gene Regulation &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, silencer elements; Gene silencing, RNA interference, miRNA, si-RNA.

#### **Text books:**

- ✓ Karp G, Iwasa J, Marshall W. Karp's Cell and Molecular Biology, 9<sup>th</sup> Edition. John Wiley and Sons. Inc. ISBN: 978-1-119-59816-9
- ✓ Krebs JE, Goldstein ES, Kilpatrick ST. (2018) Lewin's Gene XII, Jones and Bartlett Publishers, Inc. ISBN: 9781284104493.
- ✓ DeRobertis E. D. P. (2017) Cell and Molecular Biology 8<sup>th</sup> Edition. ISBN: 10-8184734506, 13-978-8184734508
- ✓ Lodish H, Berk A, Kaiser CA, Kreiger M, Bretscher A, Ploegh H, Amon A, Martin KC. (2016) Molecular Cell Biology.8<sup>th</sup> Edition. WH Freeman. ISBN: 10-1464183392, 13-978-1464183393

#### **Suggested Readings:**

- ✓ Becker W. M., Kleinsmith L.J., Hardin J, Bertoni G.P. (2009). *The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.*
- ✓ Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (2002) *Molecular Biology of the Cell, 4<sup>th</sup> Edition. ISBN: 10-0815332181, 13-978-0815332183*
- ✓ Cooper G.M. and Robert E. Hausman R.E. *The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.*
- ✓ McLennan A., Bates A., Turner, P. and White M. (2015). *Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.*
- ✓ *Lewin's Genes XII- by Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick*

### **Molecular Biology**

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. Quantitative estimation of calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A 260 nm measurement).
6. Quantitative estimation of RNA using Orcinol reaction.
7. Study and interpretation of electron micrographs/photograph showing (a) DNA replication, (b) Transcription and (c) Split genes.

### **Semester-VI**

## **Core XIV**

## **Developmental Biology**

### **Programme Outcome:**

- Understand the phases of development, changes, regulation and the concepts of ageing and teratogenesis.
- Gain knowledge on In- Vitro fertilization and amniocentesis.

### **Course Outcome:**

- Understand the basic concepts of gametogenesis, fertilization and embryogenesis.
- Gain knowledge on interferences in developmental biology.

### **Learning Outcome:**

- Apprise the historical perspectives of Developmental Biology with the basic concepts.
- Understanding of the phases and changes associated with early, late and post-embryonic development

### **Unit 1: Introduction to Developmental Biology, Gametogenesis & Fertilization**

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division. Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy.

### **Unit 2: Early Embryonic Development**

Cleavage: Planes and patterns of cleavage, Types of Blastula, Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

### **Unit 3: Late Embryonic Development**

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

### **Unit 4: Post Embryonic Development & Interferences in Developmental Biology**

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

### **Text Books:**

- ✓ *Lewis Wolpert (2010). Principles of Development. II Edition, Oxford University Press.*
- ✓ *Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.*

### **Suggested Readings:**

- ✓ *Carlson, R. F. Patten's Foundations of Embryology.*
- ✓ *Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.*
- ✓ *Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).*

## **Developmental Biology**

### **Practical:**

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.
6. Study of developmental stages by raising chick embryo in the laboratory.
7. Estimation of calcium in egg shell.
8. Estimation of carbohydrates and proteins in egg.

**Programme Outcome:**

- Familiarize learners with concepts of Taxonomy.
- Gain overview of the beginning of life and evolutionary theories.
- Understand various physical forces or stress pressures during evolution.
- Gain knowledge on correlates of epigenetic changes in the cellular footprints of animals and genetic lineages exerted through various physical forces.
- Comprehend the origin of evolution in Hominides with reference to Primates, validate evidence of human origin by molecular and phylogenetic sequence analysis.

**Course Outcome:**

- Understand concepts of taxonomy.  
Obtain knowledge of life initiation and its evolution through the chronological landscape.
- Know the evolutionary relationship of organisms with response to various physical forces leading to adaptive evolution.
- Strengthen student's analytical approach to evolutionary relationships.

**Learning Outcome:**

- Acquisition of knowledge on concepts of taxonomy and species.
- Acquaint learners with theories of evolution, evidences, and the process of changes over time.
- Gain knowledge on construction and interpretation of phylogenetic tree in relation to evolution.

**Unit 1: Concepts of Taxonomy**

Importance & Applications of biosystematics; taxonomic characters, Hierarchy categories; biological classification; Taxonomic procedures: collections, preservation, curation, identification, Keys; International Code of Zoological Nomenclature (ICZN): operative principles, important rules; Zoological nomenclature; Chemo and sero taxonomy, Cytotaxonomy, Numerical taxonomy, and DNA barcoding. Taxonomic publications: Kinds, Major features of manuscript for publication.

**Unit 2: Theories, Evidences of Evolution and Extinction**

Life's Beginnings: Chemogeny, RNA world, Biogeny, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse), Sources of variations: Heritable variations and their role in evolution. Extinctions, Background and mass extinctions (causes and effects), detailed example of K-T extinction.

**Unit 3: Process of Evolutionary changes**

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

#### **Unit 4: Products of evolution, Species concept, Origin and Evolution of man**

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric, Parapatric. Adaptive radiation/ macroevolution (exemplified by Galapagos finches). Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin. Phylogenetic trees, multiple sequence alignment, construction and interpretation of phylogenetic trees.

#### **Text Books:**

- ✓ *Principle of Animal Taxonomy*; G.G. Simpson. Oxford IBH Publishing Company.
- ✓ *Elements of Taxonomy*. E. Mayer.
- ✓ *The diversity of life (The College Edition)*, E.O. Wilson. W.W. Northern & co.
- ✓ *Theory and Practice of Animal Taxonomy*. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.
- ✓ *Advancement in Invertebrate Taxonomy and Biodiversity*. Rajeev Gupta. Agrobios International. Campbell, N.A. and Reece J.B (2011). *Biology*. IX Edition. Pearson, Benjamin, Cummings.
- ✓ Rastogi B.B., (2018). *Organic Evolution*, MedTech; 3<sup>rd</sup> edition

#### **Suggested Readings:**

- ✓ B.K. and Hallgrimson, B. (2008). *Evolution IV Edition*. Jones and Barlett Publishers.
- ✓ Douglas, J. Futuyma (1997). *Evolutionary Biology*. Sinauer Associates.
- ✓ Ridley, M (2004) *Evolution III Edition* Blackwell publishing Hall.



## **Practical**

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

## **Text Books**

- ✓ *Principles of Taxonomy by Ashok Verma.*
- ✓ *Evolutionary Biology with Practical by Tripurari Mishra.*

## **Semester VII**

### **Core XVI**

### **Instrumentation and Techniques**

**Programme Outcome:**

- The programme will impart the basic understanding on instrumentation and techniques.
- Students will gain knowledge on working principles of scientific equipment's.
- Programme strengthens student's skills in handling laboratory equipment's and performing experiments.

**Course Outcome:**

- Insights into basic understanding of instruments and their operational principles.
- Students will gain knowledge on principles of centrifugation, and chromatographic techniques like Paper chromatographic, TLC, Column chromatography (GC, GEC, Ion-exchange, affinity and HPLC).
- Course will strengthen the learners on basic techniques on gel electrophoresis and blotting.

**Learning Outcome:**

- Understand the basic principles of microscopy, spectrophotometer and radioisotope techniques.
- Gain knowledge on principle and techniques of centrifugation and chromatography.
- Knowledge in electrophoresis and blotting technique.

**Unit I:**

Instrumentation and operation: Principle of Light, Fluorescence and Electron Microscopes and their applications.

UV-Visible absorption Spectroscopy: Principle, instrumentation and application.

Principles of electrochemical techniques: Electrochemical cells and reactions, potentiometry and voltammetry, pH electrode.

Radioisotope techniques: Measurement of radioactivity in biological materials (carbon dating, Geiger-Muller counting and liquid scintillation counting).

**Unit II:**

Centrifugation techniques: Basic principles of sedimentation, Rotor types, Types of centrifugation.

Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

### **Unit III:**

Electrophoretic techniques: Principle and applications of electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels) and Nucleic acids (Agarose gel electrophoresis).

### **Unit IV:**

Blotting techniques: Principle, Instrumentation and applications (Southern, Northern and Western blotting). Flow cytometry; Basic principle, Instrumentation and application.

### **Text Book Reading:**

- ✓ *Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)*
- ✓ *Biophysical Chemistry: Principles and techniques – Upadhyay A, Upadhyay K and Nath N (Himalaya Publishing House).*
- ✓ *An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).*
- ✓ *A Textbook of Biophysics- R N Roy (NCBA, New Central Book Agency)*

### **SUGGESTED READING**

- ✓ *Mark F. Vitha. 2018. Spectroscopy: Principles and Instrumentation. Wiley, ISBN: 978-1-11943660-7.*
- ✓ *Kay Ohlendieck and Stephen E. Harding. 2017. Centrifugation and ultracentrifugation. Basic principles of sedimentation.*
- ✓ *Baraem Ismail and Suzanne Nielsen. 2010. Basic Principles of Chromatography. Food Science Texts Series, DOI 10.1007/978-1-4419-1478-1-27.*
- ✓ *Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.*

## **Practical**

### **Instrumentation and Techniques**

1. Calibration of pH meter using standards and determine the pH of water samples.
2. Isolation of genomic DNA from animal tissue/blood.
3. Quantification and purity check of isolated DNA.
4. Agarose gel electrophoresis of DNA.
5. SDS PAGE (Demonstration).
6. Isolation of Mitochondria.
7. Study of Microscopic methods.
8. Study of Microtomy and Histological techniques.
9. Blotting (Demonstration).

**Core XVII**

**Biostatistics and Bioinformatics**

**Programme Outcome:**

- The programme gives the information to students on concepts of biostatistics and bioinformatics.
- The knowledge of biostatistics gives the dynamics application of population sampling methods and utilities through various methods and statistical tools.
- The study of bioinformatics will impart the deep knowledge on various informatics tools and web resources for analysis of cellular biomolecules.

#### **Course Outcome:**

- To understand the various methods of sampling towards qualitative and quantitative analysis of its distributions in population.
- Students will be acquainted with the measures of central tendency and dispersion through mean, median and mode.
- Learners will be able to understand the function and application of probability distribution, hypothesis testing and principal component analysis.
- This course will make the students understand the biological data bases through various web resources by studying bioinformatics.

#### **Learning Outcome:**

- Studying this course student will utilize their knowledge of statistical analysis while working with biological samples and applying its functional applicability through bioinformatics.
- Students will be able to disseminate the concept of central tendency and dispersion, measure of ranges, variance, and deviations.
- Learning outcome on probability theory and distribution will make the student understand the concept of dispersion and its distribution, hypothesis testing and principal component analysis.
- Students will gain the knowledge on utilizing bioinformatics web resources for structural and functional analysis of biological macromolecules.

### **Unit-I**

Introduction: definition and scope of biostatistics. Concepts of population and methods of sampling. Simple random sampling, stratified sampling, systematic and clustered sampling. Types of biological data: Qualitative and quantitative, cross sectional and time series, discrete and continuous. Data Measurement scales: Nominal, ordinal, interval and ratio. Data presentation: Tabular and graphical. Histogram and Frequency distribution, cumulative frequency distributions and its graphical representation.

### **Unit-II**

Basic concept of measures of Central tendency and Dispersion. Mean, Median and Mode. Arithmetic, Geometric and Harmonic means. Measure of Range, Variance (sample and

population), Quartile deviation, Mean deviation, Standard deviation and their relative measures.

### Unit-III

Probability distributions: Normal (Dispersion percentage & Z-score) and binomial distribution. Inferential statistics: Hypothesis testing (Null hypothesis), p-value,  $X^2$  test, t-test (one sample t-test and paired sample t-test). Principal component analysis.

### Unit-IV

Introduction to bioinformatics and its web resources: NCBI, EMBL-EBI, ExPASy, etc. Biological data resources, access and management. Various genome across the tree of life and major sequencing projects. Data base to store and analyze DNA, RNA, protein sequences and 3-D structures (motifs and domains). Local and Global Sequence alignment programs. Genome and protein BLAST. Scoring matrices, E-value and Bit-score. OTUs and molecular phylogenetics.

### Text Book Reading:

- ✓ *Basics Biostatistics- GBN Chainy (Kalyani publishers)*
- ✓ *Biostatistical analysis- Jerrold H. Zar 5<sup>th</sup> Edition*
- ✓ *Introduction to Bioinformatics- Arthur M Lesk (Oxford University Press)*

### Suggested Reading:

- ✓ *Welham, S. J, Gezan, S. A, Clark, S. J, Mead, A. 2014. Statistical Methods in Biology [electronic resource]. Design and Analysis of Experiments and Regression Hoboken: CRC Pres.*
- ✓ *Pavan Kumar Agrawal and Rahul Shrivastava. 2017. Bioinformatics Database Resources chapter – 4. DOI: 10.4018/978-1-5225-1871-6.ch004*
- ✓ *Basic Statistical analysis- Richard C. Sprinthall - 9<sup>th</sup> edition (Pearson)*
- ✓ *Fundamentals of Biostatistics- Bernard Rosner- 8<sup>th</sup> edition (Brooks/Cole)*

### Practical

1. Data presentation by histogram and frequency tables (diagrams and graphs).
2. Determination of Arithmetic mean, geometric mean and harmonic mean.
3. Analysis of problems on Mean, Median and Modes.
4. Analysis of problems on  $X^2$  test, t-test.
5. Analysis of problem on Assumption and validations of Hypothesis testing.
6. Use of bioinformatics tools (online) for analysis of sequence similarity of DNA, RNA and Proteins.

### Core XVIII

### Animal Biotechnology

### Programme Outcome:

- Acquires knowledge on animal biotechnology.
- Gain knowledge of techniques in molecular biology and genetic engineering.
- Skills learners on methods of animal cell culture, Recombinant DNA technology and gene therapy.

#### **Course Outcome:**

- Students gain understanding of cloning vectors, restriction enzymes, genomic and cDNA libraries.
- Understand the process and applications of genetically modified organisms/ animals.

#### **Learning Outcome:**

- The study outcome will help the students in applying their knowledge of animal biotechnology in biological research and pharmaceuticals.
- Molecular techniques strengthen learners for extrapolating the functional relevance of nucleic acid.
- Gain knowledge on transgenics and knockout mice.
- Acquire skills in animal cell culture and cloning, expression of transgenes, recombinant protein production, and gene therapy.

#### **Unit 1: Introduction to Animal Biotechnology**

Concept and scope of biotechnology, cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC and Expression vectors (characteristics).

Restriction enzymes: Nomenclature, detailed study of Type II, Construction of genomic and cDNA libraries and screening by colony and plaque hybridization Transformation techniques: Calcium chloride method and electroporation

#### **Unit 2: Molecular Techniques**

Blotting: Southern, Northern and Western blotting, DNA sequencing: Sanger method Polymerase Chain Reaction, DNA Finger Printing and DNA microarray

#### **Unit 3: Genetically Modified Organisms**

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection, Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock-out mice.

#### **Unit 4: Culture Techniques and Applications**

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

Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

**Text Books:**

- ✓ *BD Singh, (2014) Biotechnology: Expanding Horizons, Kalyani Publishers*
- ✓ *U.Satyanarayana and U Chakrapani, (2014) Biotechnology, Books & Allied Ltd*
- ✓ *T.A. Brown. (2016) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell. ISBN-10-9781119072560*
- ✓ *S.B. Primrose and R.M. Twyman (2006) Principles of Gene Manipulation and Genomics. 7<sup>th</sup> Edition. Wiley-Blackwell. ISBN: 978-1-405-13544-3*
- ✓ *Richard J. Reece (2003) Analysis of Genes and Genomes. 8<sup>th</sup> Edition. ISBN: 978-0-470-84380-2*

**Suggested Readings:**

- ✓ Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
- ✓ Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.
- ✓ Brown, T.A. (2015). Gene Cloning and DNA Analysis. 7th Edition, Academic Press, California, USA.

**Practical**

**Animal Biotechnology**

1. Genomic DNA isolation from E. coli / Animal tissue
2. Plasmid DNA isolation (pUC 18/19) from E. coli
3. Restriction digestion of plasmid DNA / Lambda Phage DNA
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques through photographs
  - a. Southern Blotting
  - b. Northern Blotting
  - c. Western Blotting



d. DNA Sequencing (Sanger's Method)

e. PCR

f. DNA fingerprinting.

**Programme Outcome:**

- Imparts the knowledge of immunological defense system of human body.
- Understand the type and functions of various immune cells.
- Learner gain knowledge on primary functions of immune system and role of vaccine in combating disease.

**Course Outcome:**

- Knowledge on types and cells of immune system and their functions in physiological defense against pathogens.
- Understand the functions of various antigens and immunoglobins in cellular response.
- Learners gain knowledge of structure and function of cell surface and secreted molecules.
- Understand naturally occurring allergens and their role in hypersensitive reactions.

**Learning Outcome:**

- Gain of knowledge and expertise in the field of immunology to cater to the functional applicability of immunological defence in health care management.
- Learner acquainted with structural components of immune cells with their functions like antigenicity, immunogenicity and antigen antibody interactions.
- Understand the role of MHC, Cytokines, and Complement system in immunological defence.
- Gain knowledge on immune cells eliciting hypersensitive reactions and types of vaccines and production.

**Unit 1: Innate and Adaptive Immunity**

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.

**Unit 2: Antigens and Immunoglobulins**

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA- Direct, Indirect, Competitive, Sandwich and RIA).

**Unit 3: Major Histocompatibility Complex, Cytokines and Complement system**

Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation; Cytokines – Types, properties and functions, Complement System -Components and pathways of complement activation.

**Unit 4: Hypersensitivity and Vaccines**

Gell and Coombs' causes of hypersensitive reactions, classification and brief description of various types of hypersensitivities.

Vaccines -various types of vaccines, Advances in vaccine production.

**Text Books:**

- ✓ *Abbas K. Abul and Lechtman H. Andrew (2017). Cellular and Molecular Immunology. V Edition. Saunders Publication.*
- ✓ *Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2017). Immunology, VI Edition. W.H. Freeman and Company.*
- ✓ *Fahim Halim Khan (2009). The Elements of Immunology. Pearson Education.*

**Suggested Readings:**

- ✓ *Peter J. Delves and Seamus J. Martin (2017) Roitt's Essential Immunology, Wiley-Blackwell; 13th edition.*
- ✓ *Immunology- Weir*
- ✓ *Lab manual in Biochemistry, Immunology and Biotechnology- Arti Nigam and Archana Ayyagari (McGraw-Hill Education (India)).*

**Practical**

1. Study of lymphoid organs.
2. Histological study of spleen, thymus, skin and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of White blood cells.
4. ABO blood group determination.
5. Total WBC counting.
6. Differential count.
7. WIDAL Test.
8. Demonstration of ELISA.
9. Demonstration of Bone marrow smears to study Immune cells.

**Semester VIII**

**Core XX**

**Aquatic Biology and Toxicology**

**Programme Outcome:**

- Acquire knowledge on aquatic biomes
- Gain understanding of the fresh water and marine realm and the factors influencing the systems.
- Obtain information on management of resources associated with such systems.

**Course Outcome:**

- Skills obtained in estimating environmental parameters in the laboratory.
- Taxonomic basis of identification established.
- Prepare the students for career in aquatic resources management and sustainable utilization

**Learning Outcome:**

- Acquire knowledge about Ocean, sea floor profile and mangroves.
- Gain knowledge about beneficial bioactive compounds from marine system.
- Understand relationship between toxicant dose concentration and response.
- Gain knowledge about POP's, contaminants and their mode of action.

**Unit 1: Aquatic Biomes**

Brief introduction of the aquatic biomes: Fresh water ecosystem (lakes, wetlands, streams and rivers); Marine ecosystem (Differences between Seas and oceans, profile of floor, zones (intertidal, oceanic, pelagic, benthic), estuaries- structure and types, coral reefs and mangroves.

**Unit 2: Fresh water and Marine Biology**

Lakes: Origin and classification, Lakes and Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification,

Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbondioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous **Streams:** Different stages of stream development, Physico-chemical, environment, Adaptation of hill-stream fishes.

Seas and Oceans: Physico-chemical environmental factors in a marine environment, Adaptations of deep-sea organisms. Plankton, nekton, and benthos; Animal associations in marine environment- Natural associations-community, commensalism, parasitism, symbiosis in different groups; Marine Resources-algal, animal, mineral and Drugs.

**Unit 3: Toxicology**

Introduction to Toxicology: Sub disciplines of Toxicology, Dose-Response graphs, acute and chronic toxicity, Measurement of LD50 and LC50 values, Bioassay with examples (Vertebrate and Invertebrate).

#### **Unit 4: Mechanism of Toxicity**

Mechanisms of Toxicity of OCIs, OPIs group of pesticides, Delivery, Absorption, Distribution, Excretion, Biotransformation, Bioaccumulation, Biomagnification, Risk Assessment, Hazard Identifications (Assessing Toxicity of Chemicals), POPs (Persistent organic pollutants), Metals (Arsenic, Lead, Mercury).

#### **Text Books:**

1. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1<sup>st</sup> Edition.
2. Trivedi and Goyal: Chemical and biological methods for water pollution studies Welch: Limnology, Vols. I-II.
3. Techniques in Aquatic Toxicology, Vol-II (Gary K. Ostrader Edn.), Routledge, Taylor & Francis Group, USA.
4. A textbook of Marine ecology – N B Nair and D M Thumphy

#### **Suggested Readings:**

1. Anathakrishnan: Bioresources Ecology 3<sup>rd</sup> Edition
2. Odum and Barrett: Fundamentals of Ecology, 5<sup>th</sup> Edition
3. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1<sup>st</sup> Edition
4. Trivedi and Goyal: Chemical and biological methods for water pollution studies
5. Welch: Limnology, Vols. I-II
6. George Karleskint, James Small, Richard Turner: Introduction To Marine Biology
7. John H Duffs.; Howard G J Worth.; (Editors). (2015). "Fundamental Toxicology". 2<sup>nd</sup> Edition Publisher: Royal Society of Chemistry; UK, 516 pages
8. Environmental toxicology; John H. Duffs, 1980, Edward Arnold Publishers, New Delhi.
9. Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.
10. Fundamentals of Aquatic Toxicology; Rand, G.M and Petrocelli, S.R.(Eds), (1985), Hemisphere Publishing Corporation, Washington.

#### **Practical**

1. Determine the area of a lake using graphimetric and gravimetric method.

2. Identify the important macrophytes, phytoplankton, zooplankton and benthos.
3. Determine the amount of Turbidity/ transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a water body.
4. Instruments used in limnology/ marine Biology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, quadrat, grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/ Marine bioreserve/ Fisheries Institutes/ one time field study.

**Programme Outcome:**

- Understand the significance of wild life conservation.
- Gain knowledge on wild life and the need of habitable environmental parameters.
- Acquire skills on conservation strategies and wild life management.

**Course Outcome:**

- Gains overview of wild life conservation strategies through various acts and regulatory agencies.
- Strengthens learner's towards understanding scientific approaches to evaluate health status of wild animals and focus man-animal conflicts.

**Learning Outcome:**

- Acquire knowledge about the importance of conservation.
- Gain knowledge about implementation of wildlife laws.
- Understand methods of estimating population.
- Understand major conservation projects and maintenance of sanctuaries.

**Unit 1: Introduction to Wildlife**

Values of wild life: Positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies, Conservation and protection Laws, Wild animal of India and Odisha. Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

**Unit 2: Management of Habitats**

Setting back succession; Grazing logging; Mechanical treatment; Advancing the succession process; Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats, *In-situ* and *Ex-situ* conservation, Wild life Protection acts, Wildlife trade and its related laws.

**Unit 3 Population estimation**

Attributes of population: Density, natality, mortality, sex ratio computation, Bayesian models in abundance estimation (Spatial and Non Spatial); Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Census methods; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals.

#### **Unit 4 Management planning of wildlife in protected areas**

Estimation of carrying capacity; Ecotourism/ wildlife tourism in forests; Concept of climax persistence; Ecology of perturbation, National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation: Tiger reserves in India; Management challenges in Tiger reserve.

#### **Text Books:**

1. The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.
2. Gopal Rajesh (2011) Fundamentals of Wildlife Management, Natraj Publishers.
3. Caughley G and Sinclair ARE. (1994). Wildlife Ecology and Management. Blackwell Science.

#### **Suggested Readings:**

1. Woodroffe R, Thirgood S and Rabinowitz A (2005) People and Wildlife, Conflictor Co-existence? Cambridge University.
2. Bookhout TA (1996). Research and Management Techniques for Wildlife and Habitats, 5<sup>th</sup> Edition. The Wildlife Society, Allen Press.
3. Sutherland WJ (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.
4. Hunter ML, Gibbs JB and Sterling EJ (2008) Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

#### **Wildlife and Conservation**

1. Study of equipments used in sample collection (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
2. Study of museum specimens/ pictures (relevant to Wild Life).
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Determination of population density in a natural/ hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.



5. Identification and Demonstration of different field techniques of fauna ( Odisha and India)
6. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers, animal sounds.
7. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
8. Submission of field study report (national park/ reserve forest/ sanctuary).
9. Visit to Forest/ Wildlife Sanctuary/ Biodiversity Park/ Zoological Park to study animals and prepare a short report.

**Programme Outcome:**

- Trace the origin and history of Ethology; appreciate significant contributions of notable animal behavior researchers.
- Understand behavior patterns, comprehend the physiology underlying behavioural expressions, and acquire knowledge regarding field and laboratory study of animal behaviour.
- An understanding of social and sexual behavior.
- Relate cues to chronobiological events and understand biological rhythms and their significance.

**Course Outcome:**

- Demonstrate the ability to comprehend and gauge animal behavior in context.
- Be able to evaluate behavior with the tools and techniques learned.

**Learning Outcome:**

- Acquisition of knowledge on ethology and significant contributions of researchers in the field.
- Capability to effectively understand behavioral learning patterns
- A keen sense of observation, inquiry, and capability for understanding social behavior
- Understand chronobiological behavioral patterns.

**Unit 1: Animal Behaviour**

Origin and history of Ethology and Behavior as a discipline of science; Brief profiles of Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Tools and techniques of behavioral studies; Proximate and ultimate behavior; Innate behavior, Instinct, Stimulus filtering, Sign stimuli, and Code breakers.

**Unit 2: Patterns of Behaviour**

Stereotyped Behaviours (Orientation, Reflexes); Individual behavioral patterns; Instinct vs Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting; Reproductive behaviour patterns- Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), courtship, mating systems, parental care (fish, amphibians, birds, and mammals).

**Unit 3 Social Behaviour**

Social Behaviour: Concept of Society; Communication and the senses; Pheromones; Altruism; Insects' society with Honey bee as an example; Foraging in honey bee and advantages of the waggle dance. Hormones, drugs and behaviour.

**Unit 4: Chronobiology**

Historical developments in chronobiology; Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks, Relevance of biological clocks, Types and characteristics of biological rhythms: Short-and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic- and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin.

### **Text Books:**

- ✓ *John A (2009) Animal Behaviour. 9<sup>th</sup> Edition, Sinauer Associate Inc., USA.*
- ✓ *Vinod Kumar (2002) Biological Rhythms: Narosa Publishing House, Delhi/ Springer-Verlag, Germany.*

### **Suggested Readings:**

- ✓ *AK Pati. Chronobiology: The Dimension of Time in Biology and Medicine. PINSA (Biological Sciences). Part B67 (6) 323-372, Dec., 2001.*
  - ✓ *David Mc F. Animal Behaviour. Pitman Publishing Limited, London, UK.*
  - ✓ *Manning A and Dawkins MS. An Introduction to Animal Behaviour. Cambridge University Press, USA.*
  - ✓ *Paul WS and John A (2013) Exploring Animal Behaviour. 6<sup>th</sup> Edition. Sinauer Associate Inc., Massachusetts, USA.*
1. Jay C. Dunlap, Jennifer J. Loros, Patricia J. DeCoursey (Ed). 2004, Chronobiology Biological Time Keeping: J, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.

## **Chronobiology and Animal Behavior**

### **Practical**

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

**Required List of equipments including software with appropriate cost and possible vendors can be provided.**

1. UV Spectrophotometer Systronics approximate cost 2.5 Lakhs.
2. pH meter Systronics approximately cost 15 thousand.
3. Magnetic stirrer with hot plate with digital speed indicator Remi appropriate cost 15 thousand.
4. Hot Plate
5. Digital Balance 1 lakh INR
6. Centrifuge Remi
7. Laminar air flow
8. Deep Freezer -20
9. Students' microscopes, Dissecting Microscope, Binocular microscope, Trinocular microscope
10. Cyclomixers/Vortex Mixers
11. Water Distillation unit
12. Biological Incubator
13. Hot Air Oven
14. Micropipette/Autopipette set with variable volume (10 microlitres, 100 microlitres, and 1 microlitre)
15. Water Bath with shaker
16. Semi-automatic Microtome
17. Horizontal and vertical electrophoretic system with power pack
18. Autoclave
19. Fermenter of capacity 3 L to 5 L
20. Thermal Cycler (PCR)
21. Museum specimens representing all the taxa under study.
22. SPSS Software for statistics

#### APPENDIX-2

#### SAMPLE QUESTION SET

### UG (NEP) C-I ZOOL -1.1.1 (Non-Chordates I: Protista to Pseudocoelomates) END SEMESTER EXAMINATION (2024 BATCH ONWARDS) MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

#### PART-I

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units)

**[1]**

- Q 1. a) Muscular swellings or lappets are typical of the larva stage.....of *Fasciola hepatica*.

#### PART-II

(At least two questions from any of the units) [2]

Q 2. a) Write the unique features of Class Phytomastogophorea?

**PART-III**

(At least two questions from any of the units) [5]

Q 3. a) What is the evolutionary significance of Ctenophora?

**PART-IV**

(At least two questions from any of the units) [8]

Q 4. a) How are helminths adapted to a parasitic mode of life?

**OR**

b) What are the typical features of Nematelminthes?



**UG (NEP) C-I ZOOL -2.3.3 (Principles of Ecology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

- Q 1. a) The process by which a plant or animal becomes established in a new habitat is known as \_\_\_\_\_.

**PART-II**

(At least two questions from any of the units) [2]

- Q 2. a) What are the difference between R and K strategies?

**PART-III**

(At least two questions from any of the units) [5]

- Q 3. a) What do you understand by mode of a data series? State how is it calculated for ungrouped and grouped data? Give a practical situation where you will recommend the use of mode.

**PART-IV**

(At least two questions from any of the units) [8]

- Q 4. a) Why ecotone is known as the zone of stress? Explain with examples that why the productivity is higher in transitional zones of ecosystem

**OR**

- b) Define survivorship curve. Describe the three general types of survivorship curves with examples. How is the survivorship curve used?

**UG (NEP) C-I ZOOL -2.4.1 (Physiology I)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

- Q 1. a) G proteins are made up of ----- subunits.

**PART-II**

(At least two questions from any of the units)

[2]

- Q 2. a) Differentiate between G-actin and F- actin.

**PART-III**

(At least two questions from any of the units)

[5]

- Q 3. a) Why are skeletal muscle fibers fast contracting?

**PART-IV**

(At least two questions from any of the units)

[8]

- Q 4. a) Explain the four steps of cross-bridge cycle and add a note on ATP generation pathway in a skeletal muscle.

**OR**

- b) How does the stimulus pass through synaptic cleft? List the main events.





**UG (NEP) C-I ZOOL -2.3.2 (Cell Biology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

- Q 1. a) Microtubules are made up of long hollow cylinder of protein components known as \_\_\_\_\_.

**PART-II**

(At least two questions from any of the units)

[2]

- Q 2. a) What do you mean by semi-autonomous nature of mitochondria?

**PART-III**

(At least two questions from any of the units)

[5]

- Q 3. a) Describe how GTP hydrolysis destabilizes microtubule polymerization.

**PART-IV**

(At least two questions from any of the units)

[8]

- Q 4. a) Describe the structure of nuclear envelope proteins and its function in cell division.

**OR**

- b) Describe the various models of plasma membrane structure in brief.



**UG (NEP) C-I ZOOL -1.2.1 (Chordates)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

[1]

(One mark each in the form of fill in the blanks/one word answer covering all units)

- Q 1. a) There are two main groups of fish, namely \_\_\_\_\_ and \_\_\_\_\_ based on the composition of the endoskeleton.

**PART-II**

[2]

(At least two questions from any of the units)

- Q 2. a) Specify the environmental factors might have led to the evolution of the tetrapod limb?

**PART-III**

[5]

(At least two questions from any of the units)

- Q 3. a) What is the difference between the continental drift hypothesis and the plate tectonics theory?

**PART-IV**

[8]

(At least two questions from any of the units)

- Q 4. a) Write in brief the significance of larval forms of protochordates in phylogenetic studies of Chordates ?

**OR**

What is retrogressive metamorphosis? Describe in detail retrogressive metamorphosis in *Herdmania*.

**UG (NEP) C-I ZOOL -2.5.1 (Comparative anatomy of Vertebrates)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) Surface of palm, soles, fingers and toes present with series of grooves and ridges for exhibiting friction, grips and traction are known as \_\_\_\_\_.

**PART-II**

(At least two questions from any of the units) **[2]**

- Q 2. a) How many air sacs are present in avian respiratory system?

**PART-III**

(At least two questions from any of the units) **[5]**

- Q 3. a) Compare pronephrous and mesonephrous kidney system in vertebrates.

**PART-IV**

(At least two questions from any of the units) **[8]**

- Q 4. a) Give an elaborative description of epidermal derivatives of skin in vertebrates.

**OR**

What Give a comparative account of general plan of brain development in vertebrates.

**UG (NEP) C-I ZOOL -2.5.2 (Physiology-II)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) The fraction of blood composed of packed red blood cells achieved using centrifugation is known as \_\_\_\_\_.

**PART-II**

(At least two questions from any of the units) **[2]**

- Q 2. a) Name the ions responsible for inhibition of trypsin secretion in pancreas.

**PART-III**

(At least two questions from any of the units) **[5]**

- Q 3. a) What is van't Hoff's law? Explain the osmolarity and osmotic pressure of a solution.

**PART-IV**

(At least two questions from any of the units) **[8]**

- Q 4. a) Explain in brief, the transport of oxygen and exchange of carbon dioxide in blood.

**OR**

What State Frank-Starling law of heart and blood flow.



**UG (NEP) C-I ZOOL -2.7.4 (Immunology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

- Q 1. a) Dendritic cells act as -----.

**PART-II**

(At least two questions from any of the units) [2]

- Q 2. a) Explain the biochemical mechanism of respiratory burst leading to intracellular killing of microbes within the neutrophils.

**PART-III**

(At least two questions from any of the units) [5]

- Q 3. a) Explain how neutrophils recognize pathogens and role of phagocytic cells in clearing apoptotic cells.

**PART-IV**

(At least two questions from any of the units) [8]

- Q 4. a) Briefly discuss the activation process of haptens and adjuvants.

**OR**

What Write a short note on Type-III Immune complex reaction.



**UG (NEP) C-I ZOOL -2.8.3 (Chronobiology and Animal Behaviour)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

Q 1. a) Skinner box was designed to study-----.

**PART-II**

(At least two questions from any of the units) [2]

Q 2. a) Explain the relation between circannual and circadian rhythm using the example of birds.

**PART-III**

(At least two questions from any of the units) [5]

Q 3. a) Discuss the role of master genes (CLOCK and BMAL1) in regulating mammalian circadian clock.

**PART-IV**

(At least two questions from any of the units) [8]

Q 4. a) What are the characteristics of stereotype patterns of behavior? Explain spatial orientation with suitable examples?

**OR**

What Give a brief on non-photic zeitgebers and their role in entraining circadian rhythm.

**UG (NEP) C-I ZOOL -2.8.1 (Aquatic biology and Toxicology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

Q 1. a) Largest coral reef is in -----.

**PART-II**

(At least two questions from any of the units) [2]

Q 2. a) Name the three major ecological groups in aquatic biome.

**PART-III**

(At least two questions from any of the units) [5]

Q 3. a) Explain biotransformation of xenobiotics.

**PART-IV**

(At least two questions from any of the units) [8]

Q 4. a) Explain the collection and preservation mechanism of phytoplankton

**UG (NEP) C-I ZOOL -2.8.2 (Wildlife and Conservation Biology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

b) State the characteristic features of estuary.

Q 1. a) Wildlife associated telemetry is also known as-----.

**PART-II**

(At least two questions from any of the units)

[2]

Q 2. a) Discuss preservation of general genetic diversity methods.

**PART-III**

(At least two questions from any of the units)

[5]

Q 3. a) Describe grazing logging method for managing habitat.

**PART-IV**

(At least two questions from any of the units)

[8]

Q 4. a) Explain the applications of remote sensing and GIS in wildlife monitoring.

**OR**

b) Discuss In-situ conservations methods.

**UG (NEP) C-I ZOOL -2.6.2 (Development Biology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) What is the main enzyme that plays a major role in formation of thymine dimer?

**PART-II**

(At least two questions from any of the units) **[2]**

- Q 2. a) The primitive groove in chick is analogous to the amphibian blastopore. Justify?

**PART-III**

(At least two questions from any of the units) **[5]**

- Q 3. a) What is an embryonic inductor? Explain the role of the roof of the archenteron in embryonic induction.

**PART-IV**

(At least two questions from any of the units) **[8]**

- Q 4. a) Describe the structure of the placenta, and discuss its types and functions.

**OR**

- a) Explain the changes that take place during the metamorphosis of frogs and the

hormonal regulation of the same.

**UG (NEP) C-I ZOOL -2.3.1 (Microbiology)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units)

**[1]**

- Q 1. a) Entry of enveloped viruses into host cells is mediated by membrane fusion and .....

**PART-II**

(At least two questions from any of the units)

**[2]**

- Q 2. a) What are the major differences between transformation and transduction?

**PART-III**

(At least two questions from any of the units)

**[5]**

- Q 3. a) Explain the role of microbes in health care and agriculture with suitable examples.

**PART-IV**

(At least two questions from any of the units)

**[8]**

- Q 4. a) Explain the different types of microbial toxins and their mode of action.

**OR**

- a) Explain the significant features of Bergey's manual for the classification of microbes.

**UG (NEP) C-I ZOOL -2.6.1 (Molecular Biology)**

**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**

**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

Q 1. a) What is the main enzyme that plays a major role in formation of thymine dimer?

**PART-II**

(At least two questions from any of the units) **[2]**

Q 2. a) Differentiate between B DNA and Z DNA?

**PART-III**

(At least two questions from any of the units) [5]

Q 3. a) With the help of suitable diagrams describe the mechanism of transcriptional termination in prokaryotes.

**PART-IV**

(At least two questions from any of the units) [8]

Q 4. a) Discuss the mechanism of gene regulation in Tryptophan Operon.

**OR**

a) Explain the sequence of events during DNA replication in eukaryotes and explain the role of various enzymes.

**UG (NEP) C-I ZOOL -2.5.3 (Fundamentals of Biochemistry)**

**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**

**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

Q 1. a) What is the total number of ATP molecules produced from ADP by glycolysis of one glucose molecule?

**PART-II**

(At least two questions from any of the units)

**[2]**

- Q 2. a) Differentiate between Glycogenolysis and Glycogenesis?

**PART-III**

(At least two questions from any of the units)

**[5]**

- Q 3. a) Explain the Inhibitors and un-couplers of the Electron Transport System.

**PART-IV**

(At least two questions from any of the units)

**[8]**

- Q 4. a) Give an account of  $\beta$  – the oxidation of saturated, even carbon fatty acid, along with its energetics and regulation.

**OR**

- a) Explain the process and purpose of ketogenesis.



**UG (NEP) C-I ZOOL -2.4.2 (Fundamentals of Biochemistry)**  
**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**  
**MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units)

**[1]**

- Q 1. a) Individual monosaccharides are linked by .....to form polysaccharides

**PART-II**

(At least two questions from any of the units)

**[2]**

- Q 2. a) What are nucleosides and nucleotides?

**PART-III**

(At least two questions from any of the units)

**[5]**

- Q 3. a) Explain the mechanism of enzyme action.

**PART-IV**

(At least two questions from any of the units)

**[8]**

- Q 4. a) Explain the basic structure of Immunoglobulins. Discuss their classes and functions.

**OR**

- a) Explain the structure and types of DNA.

**UG (NEP) C-I ZOOL -2.5.4 (Principles of Genetics)**

**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**

**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) In case of two gene interaction, the gene which is masking the expression of another is called\_\_\_\_\_ and the gene whose expression is masked is called\_\_\_\_\_

**PART-II**

(At least two questions from any of the units) **[2]**

- Q 2. a) Differentiate between back cross and test cross?

**PART-III**

(At least two questions from any of the units) **[5]**

- Q 3. a) Explain the types of chromosomal aberrations.

**PART-IV**

(At least two questions from any of the units) **[8]**

- Q 4. a) Give an account of Chromosomal mechanisms of sex determination in Drosophila.

**OR**

- a) Explain the process Linkage and crossing over.

**UG (NEP) C-I ZOOL -2.7.1 (Instrumentation and Techniques)**

**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)**

**MODEL QUESTION PATTERN**

**FULL MARKS: 50**

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) In liquid scintillation counter, .....is used to convert light into electrical signals.

**PART-II**

(At least two questions from any of the units) **[2]**

Q 2. a) How can we use Beer-Lambert's Law to determine the concentration of a solution?

**PART-III**

(At least two questions from any of the units) [5]

Q 3. a) What is the principle of Southern Blotting? Explain the technique and its applications.

**PART-IV**

(At least two questions from any of the units) [8]

Q 4. a) What is the principle of chromatography? Describe the types of chromatography.

**OR**

a) How is a Fluorescence microscope different from an electron microscope? Discuss their applications.

**UG (NEP) C I (ZOOL-2.7.3) ANIMAL BIOTECHNOLOGY**

**END SEMESTER EXAMINATION (2024 BATCH ONWARDS)  
MODEL QUESTION PATTERN**

TIME: 3 hours

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

**PART-I**

**Marks**

- (One mark each in the form of fill in the blanks/one word answer covering all units) [1]
- Q 1. a) The process by which a foreign DNA is introduced into bacteria is called \_\_\_\_\_?

**PART-II**

(At least two questions from any of the units) [2]

- Q 2. a) Discuss Western blotting technique.  
What is DNA microarray, and its applications?

**PART-III** [5]

(At least two questions from any of the units)

- Q 3. a) What is Polymerase Chain Reaction? Describe the principle and applications of PCR.

**OR**

- b) Describe the process of Sanger method of DNA sequencing.

**PART-IV** [8]

(At least two questions from any of the units)

- Q 4. a) Give the features of cloning and expression vector. Describe the process of expressing of cloned genes in mammalian cells

**OR**

- b) What is DNA Finger Printing? Give the process and applications of RFLP technique.

