**DEPARTMENT OF ZOOLOGY**
**SARBATI DEVI WOMEN'S COLLEGE,RAJGANGPUR**
**PO,CO,PSO- NEP-2020**

**SEMESTER I**

**PAPER I**

**Invertebrates: Protista to Echinodermata**

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the general characteristics o f 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 phylogenic 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 Nemathelminthes.

- 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

**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, Nautilu.

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.

**PAPER II**

**Diversity of Chordates: Protochordates to Mammalia**

(4Credit, Theory-45h and Practical – 30h)

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, Erinaceous.

8. Power point presentation on study of any two examples representing two different classes.. Submission of report on local species.

SEMESTER II

PAPER III Microbiology

(4Credit, Theory-45h and Practical – 30h)

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.
- Uunderstanding 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, Whittakar’ 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.

PAPER -IV

Cell Biology

(4Credit, Theory-45h and Practical – 30h)

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).

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.).

SEMESTER-III

PAPER V Principles of Ecology

(4Credit, Theory-45h and Practical – 30h)

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, quadrate 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).

**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 quadrate 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 $CO_2$, 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).

**PAPER-VI**

**Physiology: Controlling and Coordinating systems**

(4Credit, Theory-45h and Practical – 30h)

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.

**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.

**PAPER VII**

**Fundamentals of Biochemistry**

(4Credit, Theory-45h and Practical – 30h)

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 Km and Vmax, Lineweaver-

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

**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**

**PAPER VIII** **Endocrinology & Reproductive Biology**

(4Credit, Theory-45h and Practical – 30h)

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-hypophysial 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 tansduction .

Unit 2: Hypothalamo-hypophysial Axis and Regulation of Hormone Action

Structure of hypothalamus, Hypothalamic nuclei, Neurosecretions, Neurohormones and their functions, Hypothalamo-hypophysial 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.

**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. Ovarectomy, 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)

**PAPER IX**

**Comparative Anatomy of Vertebrates**

(4Credit, Theory-45h and Practical – 30h)

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 r e p o r t s u b m i s s i o n on I n t e g u m e n t a r y d e r i v a t i v e s .

**PAPER X**

**Physiology: Life Sustaining Systems**

(4Credit, Theory-45h and Practical – 30h)

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' shaemoglobinometer.
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.

**SEMESTER -V**

**PAPER XI** **Biochemistry of Metabolic Processes**

(4Credit, Theory-45h and Practical – 30h)

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

$\mathrm{B}$-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 $CO_2$ in the TCA cycle.

**PAPER XII**

**Principles of Genetics**

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

• Obtain knowledge on the basic principles of genetics. •

• To provide knowledge on the mechanism of sex determination and extrachromosomal 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 extrachromosomal

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.

**PAPER- XIII**

**Molecular Biology**

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 semidiscontinuous

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.

**PRACTICAL**

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**

**PAPER XIV** **Developmental Biology**

(4Credit, Theory-45h and Practical – 30h)

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 postembryonic 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 inductionand 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.

**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 (photomicropgraph/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.

**PAPER -XV**

**Taxonomy and Evolutionary Biology**

(4Credit, Theory-45h and Practical – 30h)

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, curetting, 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, Back ground 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.

*Multi-Disciplinary Course - SEMESTER-II*

**Paper-II: Apiculture (Zoology)**

• Provide knowledge on economic aspects of livestock management.

• Make available information on lucrative facets of animal rearing and goods obtained.

• To familiarize with apiculture features

**Course Outcomes**

• Foundation through skilled learning for entrepreneurship.

• Acquire skills in developing economically viable ventures using bees.

• To know the basic concepts of beekeeping.

• Discern bee species, understand culture techniques, honey harvesting, and the identification and management of diseases and pests.

• Students will be equipped with practical knowledge that can be immediately applied in the field or even used to start their own beekeeping enterprise

**Learning Outcomes**

• Gain knowledge of the Biology of Bees, their identification, and social structure.

• Acquire skills in rearing bees and honey extraction.

• Identify pests of bees and their control and eradication.

• Skilled learning for entrepreneurship.

**Unit 1:**

Biology of Bees: Apis and Non-Apis Bee species and their identification. General Morphology of Apis Honey Bees. Social Organization of Bee Colony.

**Unit 2:**

Rearing of Bees: Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth box, Bee Pasturage,

Selection of Bee Species for Apiculture, Modern Bee Keeping Equipment, Methods of Extraction of Honey (Indigenous and Modern).

**Unit 3:**

Diseases and Enemies: Bee Diseases and Enemies, Control and Preventive measures

**Unit 4:**

Bee Economy and Entrepreneurship: Products of Apiculture Industry and their uses- Honey, Bees Wax, Propolis, Pollen. Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens.