B.Sc. (Honors) in Zoology
Under the Framework of Honors School System
OUTLINES OF TESTS

OBJECTIVE OF THE COURSE

To teach the various concepts of Zoology and their applications, the syllabus pertaining to B.Sc. (Honors) Zoology (3 Year course & 6 Semesters) in the subject of Zoology under Honors School Framework has been upgraded as per provision of the UGC module for CHOICE BASED CREDIT SYSTEM and demand of the academic environment. The syllabus contents are duly arranged UNIT wise and contents are included in such a manner so that due importance is given to requisite intellectual and laboratory skills according to UGC.

Semester I

CORE COURSE (ZOOLOGY)

Theory Papers:
Core Course-1 (C 1): Non-Chordates I 100 Marks (4 credits)
Core Course-2 (C 2): Principles of Ecology 100 Marks (4 credits)

Practicals:
Core Course-1 Practical (C 1 Lab): Non-Chordates I 50 Marks (2 credits)
Core Course-2 Practical (C 2 Lab): Principles of Ecology 50 Marks (2 credits)

GENERIC ELECTIVE (ZOOLOGY)

Theory Papers:
Each student from other disciplines may opt any two of the generic electives offered by the Science Departments of Panjab University out of following:
Generic Elective -1 (GE-1) 100 Marks (4 credits)
Generic Elective -2 (GE-2) 100 Marks (4 credits)

Practicals:
Generic Elective -1 Practical (GE-1 Lab) 50 Marks (2 credits)
Generic Elective -2 Practical (GE-2 Lab) 50 Marks (2 credits)

EVALUATION
1. There shall be one Mid Term Examination of 20% Marks (20 marks) in each semester.
2. End-semester examination will be of 80% of total marks (80 marks).
3. Each practical examination shall be of 3 hours duration.
4. There shall be continuous internal assessment for practicals of 20% marks (10 marks). The final examination will be of 80% marks (40 marks).
Pattern of end-semester question paper
(i) Nine questions in all with equal weightage (16 marks). The candidate will be asked to attempt five questions.
(ii) One Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.
(iii) The remaining eight questions will be in Four UNITs, each unit comprising of two questions.
(iv) Students will attempt one question from each UNIT and the compulsory question.

ABILITY ENHANCEMENT COMPULSORY COURSE FOR CHEMISTRY STUDENTS
Each student of Zoology Department has to opt one Ability Enhancement Compulsory Course of the following:
1. English Communication (2 credits)
2. Environmental Science (2 credits)
Semester II

CORE COURSE (ZOOLOGY)

Theory Papers:
Core Course-3 (C 3): Non-Chordates II 100 Marks (4 credits)
Core Course-4 (C 4): Cell Biology 100 Marks (4 credits)

Practicals:
Core Course-3 Practical (C 3 Lab): Non-Chordates II 50 Marks (2 credits)
Core Course-4 Practical (C 3 Lab): Cell Biology 50 Marks (2 credits)

GENERIC ELECTIVE (ZOOLOGY)

Theory Papers:
Each student from other disciplines may opt any two of the generic electives offered by the Science Departments of Panjab University out of following:
Generic Elective -3 (GE-3) 100 Marks (4 credits)
Generic Elective -4 (GE-4) 100 Marks (4 credits)

Practicals:
Generic Elective -3 Practical (GE-3 Lab) 50 Marks (2 credits)
Generic Elective -4 Practical (GE-4 Lab) 50 Marks (2 credits)

EVALUATION
1. There shall be one Mid Term Examination of 20% Marks (20 marks) in each semester.
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1. English Communication (2 credits)
2. Environmental Science (2 credits)
B.Sc (Hons.) Zoology

Semester III

CORE COURSE (ZOOLOGY)

Theory Papers:
Core Course-5 (C 5): Diversity of Chordates 100 Marks (4 credits)
Core Course-6 (C 6): Physiology: Controlling and Coordinating Systems 100 Marks (4 credits)
Core Course-7 (C 7): Fundamentals Biochemistry 100 Marks (4 credits)

Practicals:
Core Course-5 Practical (C 5 Lab): Diversity of Chordates 50 Marks (2 credits)
Core Course-6 Practical (C 6 Lab): Physiology: Controlling and Coordinating Systems 50 Marks (2 credits)
Core Course-7 Practical (C 7 Lab): Fundamentals Biochemistry 50 Marks (2 credits)

GENERIC ELECTIVE (ZOOLOGY)

Theory Papers:
Each student from other disciplines may opt any two of the generic electives offered by the Science Departments of Panjab University out of following:
Generic Elective -5 (GE-5) 100 Marks (4 credits)

Practicals:
Generic Elective -5 Practical (GE-5 Lab) 50 Marks (2 credits)

EVALUATION
1. There shall be one Mid Term Examination of 20% Marks (20 marks) in each semester.
2. End-semester examination will be of 80% of total marks (80 marks).
3. Each practical examination shall be of 3 hours duration.
4. There shall be continuous internal assessment for practicals of 20% marks (10 marks). The final examination will be of 80% marks (40 marks).

Pattern of end-semester question paper
(i) Nine questions in all with equal weightage (16 marks). The candidate will be asked to attempt five questions.
(ii) One Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.
(iii) The remaining eight questions will be in Four UNITS, each unit comprising of two questions.
(iv) Students will attempt one question from each UNIT and the compulsory question.

SKILL ENHANCEMENT COMPULSORY COURSE
Each student of Zoology Department has to opt one Skill Enhancement Compulsory Course:
1. Skill Enhancement Course (SEC 2) (2 credits)
Semester IV

CORE COURSE (ZOOLOGY)

Theory Papers:
Core Course-8 (C 8): Comparative Anatomy of Vertebrates 100 Marks (4 credits)
Core Course-9 (C 9): Physiology: Life Sustaining Systems 100 Marks (4 credits)
Core Course-10 (C 10): Biochemistry of Metabolic Processes 100 Marks (4 credits)

Practicals:
Core Course-8 Practical (C 8 Lab): Comparative Anatomy of Vertebrates 50 Marks (2 credits)
Core Course-9 Practical (C 9 Lab): Physiology: Life Sustaining Systems 50 Marks (2 credits)
Core Course-10 Practical (C 10 Lab): Biochemistry of Metabolic Processes 50 Marks (2 credits)

GENERIC ELECTIVE (ZOOLOGY)

Theory Papers:
Each student from other disciplines may opt any two of the generic electives offered by the Science Departments of Panjab University out of following:
Generic Elective -6 (GE-6) 100 Marks (4 credits)

Practicals:
Generic Elective -6 Practical (GE-6 Lab) 50 Marks (2 credits)

EVALUATION
1. There shall be one Mid Term Examination of 20% Marks (20 marks) in each semester.
2. End-semester examination will be of 80% of total marks (80 marks).
3. Each practical examination shall be of 3 hours duration.
4. There shall be continuous internal assessment for practicals of 20% marks (10 marks). The final examination will be of 80% marks (40 marks).

Pattern of end-semester question paper
(i) Nine questions in all with equal weightage (16 marks). The candidate will be asked to attempt five questions.
(ii) One Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.
(iii) The remaining eight questions will be in Four UNITS, each unit comprising of two questions.
(iv) Students will attempt one question from each UNIT and the compulsory question.

SKILL ENHANCEMENT COMPULSORY COURSE
Each student of Zoology Department has to opt one Skill Enhancement Compulsory Course:
1. Skill Enhancement Course (SEC2) (2 credits)
**PREAMBLE**

The Department of Zoology is one of the oldest and well-established departments in North India, which has completed more than 100 years of teaching and research. It was shifted from Hoshiarpur to present campus at Chandigarh in July 1960. The department has many landmarks as its teaching and research activities changed from classical to the most recent ones in Zoology, and remained at the forefront both nationally and internationally. Based on the performance of teaching and research potentials of the staff members, UGC had recognized the Department for Special Assistance Programme (SAP) in 1985 and extended it for two terms. Under the COSIST Programme, a grant of Rs. 42.5 lakhs was sanctioned for a five year term (1996-2001). 3rd Phase of SAP started from 2001-2006 with financial aid of Rs. 65.75 lakhs. On completion of the 3rd Phase of SAP, UGC review committee upgraded the department for CAS (Centre of Advance Study) in Biodiversity: Cell and Molecular Biology, with the financial assistance of Rs. 78.25 lakhs from 2007-2012. In 2013 the department was recognised by the DST under its FIST programme and sanctioned a grant of 1.10 crores for 5 years. In 2015 the department has received grant of Rs. 161.55 lacs + 2 Project Fellows under Phase II CAS Programme.

The Department is well equipped with teaching and research laboratories. There are three laboratories for undergraduate students and two for post-graduate students where course practicals are conducted. There are six specialized laboratories for research students (M.Sc., M.Phil & Ph.D.) which are maintained as per the specific needs of the research areas including Cell and Animal Physiology, Aquatic Biology, Cytogenetics, Entomology & Parasitology. There is a central sophisticated instruments laboratory equipped with advanced instruments such as Real-time PCR, Flow Cytometer, 2D Gel Electrophoresis system, HPLC, Nanodrop etc along with other basic research instruments. The Department also has a well equipped computer lab., which are open for use by students and staff. The Department has a seminar room with modern audio visual facility and interactive class-room.

**Library**
The department library is well stocked with highly informative 10,000 textbooks and reference books having general information related to the subject of Zoology. The library also receives good scientific research journals of national and international repute for the benefit of research scholars and the faculty. New books and journals are regularly added and updated.

**Museum**
The department has two state of art museums with a wealth of 3000 specimens belonging to different animal phyla.
## COURSE STRUCTURE

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**C:** Core Courses; **GE:** General Elective; **AECC:** Ability Enhancement Compulsory Courses; **SEC:** Skill Enhancement Courses; **DSE:** Discipline Specific Elective

*: **GE subjects are to be selected by the students from the pool of GE Subjects offered by various Departments of the University.**
**SKILL ENHANCEMENT COURSES** (any one per semester in semesters 3-4)

1. BZO-SEC1: Apiculture
2. BZO-SEC2: Aquarium Fish Keeping
3. BZO-SEC3: Medical Diagnostics
4. BZO-SEC4: Research Methodology

**DISCIPLINE SPECIFIC ELECTIVE COURSES** (any two per semester in semesters 5-6)

1. BZO-DSE1: Animal Biotechnology
2. BZO-DSE2: Biology of Insecta
3. BZO-DSE3: Endocrinology
4. BZO-DSE4: Fish and Fisheries
5. BZO-DSE5: Immunology
6. BZO-DSE6: Parasitology
7. BZO-DSE7: Reproductive Biology
8. BZO-DSE8: Wildlife Conservation and Management

**Courses under these will be offered only if a minimum of 10 students opt for the same**

**GENERIC ELECTIVE SUBJECTS** (Offered by Zoology Department) for students of other departments

1. BZO-GE1*: Animal Diversity
2. BZO-GE2*: Aquatic Biology
3. BZO-GE3*: Immunology
4. BZO-GE4*: Human Physiology
5. BZO-GE5*: Insect Vector and Diseases
6. BZO-GE6*: Evolution and Palaeontology

Outlines for Semester II will be same as for Semester I

A Department will run a particular Generic Elective Course only if the minimum number of students opting for that course is 10.
B.Sc. (Hons) Course in Zoology
Semester I to IV
Semester I

BZO-C1: Non-Chordates I: Protists to Pseudocoelomates
THEORY

Total Lectures: 60
Credits: 4

Objectives:
• To enable the students to develop an appreciation for the biodiversity of invertebrate species.
• To impart knowledge about co-existence of different forms of living organisms ranging from unicellular to multicellular animals.

UNIT 1: Protista, Parazoa and Metazoa (19 hrs)
General characteristics and classification up to classes*
Study of euglena, amoeba and paramecium
Life cycle and pathogenicity of plasmodium vivax and entamoeba histolytica
Locomotion and reproduction in protista
Evolution of symmetry and segmentation of metazoa

UNIT 2: Porifera and Ctenophora (11 hrs)
Porifera: General characteristics and classification up to classes of phylum porifera*. Canal system and spicules in sponges.
Ctenophora: General characteristics and evolutionary significance of phylum ctenophora.

UNIT 3: Cnidaria (12 hrs)
Cnidaria: General characteristics and classification up to classes of phylum cnidaria*. Metagenesis in obelia, polymorphism in cnidaria, corals and coral reefs.

UNIT 4: Platyhelminthes & Nemathelminthes (18 hrs)
Platyhelminthes: General characteristics and classification up to classes*. Life cycle and pathogenicity of fasciola hepatica and taenia solium.
Nemathelminthes: General characteristics and classification up to classes*. Life cycle and pathogenicity of ascaris lumbricoides and wuchereria bancrofti. parasitic adaptations in helminthes.

*Note: Classification to be followed from “Barnes, R.D. (1982). Invertebrate Zoology, V Edition”
BZO-C1: Non-Chordates I : Protists to Pseudocoelomates

PRACTICALS

Total Lectures : 60  
Credits : 2

1. **Protozoa**: Study of whole mount of euglena, amoeba and paramecium, binary fission and conjugation in paramecium; examination of pond water collected from different places for diversity in protista.
2. **Porifera**: Study of *sycon* (T.S. and L.S.), *hyalonema, euplectella, spongilla*.
3. **Cnidaria**: Study of *obelia, physalia, millepora, aurelia, tubipora, corallium, alcyonium, gorgonia, metridium, pennatula, fungia, meandrina, madrepora*.
4. **Ctenophora**: One specimen/slide of any ctenophore.
5. **Platyhelminthes**: Study of adult *fasciola hepatica, taenia solium* and their life cycles (slides/microphotographs).

SUGGESTED READINGS

BZO-C2: Principles of Ecology

THEORY

Total Lectures : 60

Credits : 4

Objectives:

• To educate the students about the basic environmental phenomena like ecosystem, energy flow through the ecosystem and biogeochemical cycles.

• To enable the students understand the adaptations of the animals to their environment.

UNIT 1: Introduction to Ecology (15 hrs)

Introduction to Ecology: History of ecology, autecology and synecology, levels of organization, laws of limiting factors, study of physical factors.

Applied Ecology: Ecology in wildlife conservation and management

UNIT 2: Population, Growth and Regulation (15 hrs)

Concept of population: Unitary and modular populations.

Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion.

Exponential and logistic growth, equation and patterns, r and K strategies.

Population regulation - density-dependent and independent factors.

Population interactions, gause’s principle with laboratory and field examples, lotka-volterra equation for competition and predation, functional and numerical responses.

UNIT 3: Community (15 hrs)

Community characteristics: species richness, dominance, abundance, diversity indices, similarity Indices, vertical stratification.

Ecotone and edge effect.

Ecological succession.

Theories pertaining to climax community.

UNIT 4: Ecosystem (15 hrs)

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 and ecological efficiencies.

Nutrient and biogeochemical cycles.

Human modified ecosystem.
BZO-C2: Principles of Ecology
PRACTICALS

Credits: 2

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
3. Study of an aquatic ecosystem: phytoplankton and zooplankton, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler’s method), chemical oxygen demand, free CO₂ and total alkalinity.
6. Determination of similarity coefficient using Jacob and Sorensen measures.

SUGGESTED READINGS
B.Sc (Hons.) Zoology

Semester II

BZO-C3: Non-chordates II: Coelomates

THEORY

Total Lectures: 60

Credits: 4

Objectives:

- To acquaint the students with the non-chordates i.e. Annelids, Arthropoda and Mollusca, Onychophora and Echinodermata and study their functional anatomy.
- To enable the students to understand the difference in their morphology and general anatomy and to classify and study their general characters.
- To enable the students to understand the dominance of Arthropods and their association with human welfare in a number of ways.
- To impart in depth knowledge to students about the different modes of living and structural modification acquired to suit varied living conditions.

UNIT 1: Introduction to Coelomates, Annelida (12 hrs)

Annelida: General characteristics and classification up to classes, excretion, respiration and reproduction in Annelids.

UNIT 2: Arthropoda (17 hrs)

Arthropoda: General characteristics and classification up to classes, respiration in arthropods. Metamorphosis in insects, social life in:

a. Bees: Species, castes, division of labour, nest architecture and swarming.

b. Termites: Castes, Nest architecture, swarming and colony formation.

UNIT 3: Mollusca (15 hrs)

Mollusca: General characteristics and classification up to classes, respiration in mollusca, torsion and detorsion in gastropoda, pearl formation in bivalves, evolutionary significance of trochophore larva.

UNIT 4: Echinodermata and Onychophora (16 hrs)

Echinodermata: General characteristics and classification up to classes, water-vascular system in asteroidea, larval forms in echinodermata, affinities with chordates.

Onychophora: General characteristics and evolutionary significance.
BZO-C3: Non-chordates II: Coelomates

PRACTICALS

Credits : 2

1. Study of following specimens:
   **Annelids** - Aphrodite, nereis, heteronereis, sabella, serpula, chaetopterus, pheretima, hirudinaria.
   **Arthropods** - Limulus, palamnaeus, palaemon, daphnia, balanus, sacculina, cancer, eupagurus, scolopendra, julus, bombyx, periplaneta, termites and honey bees.
   **Onychophora** – peripatus.
   **Molluscs** - Chiton, dentalium, pila, doris, helix, unio, ostrea, pinctada, sepia, octopus, nautilus.
   **Echinodermates** - Pentaceros/Asterias, ophiura, clypeaster, echinus, cucumaria and antedon.

2. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm through flow chart, slides or videos.

3. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm with the help of flow charts, slides or videos.

4. Mount of mouth parts and dissection of digestive system and nervous system of *periplaneta* through flow chart, slides or videos.

5. To submit a project report on any related topic to larval forms (crustacean, mollusk and echinoderm).


**SUGGESTED READINGS**

BZO-C4: Cell Biology

THEORY

Total Lectures: 60  Credits: 4

Objectives: Cell Biology deals with the detailed study of a cell including cell structure, cell composition, cell organelles and the interaction of cells with other cells and the larger environment in which they exist.

UNIT 1: Cell and Plasma membrane (15 hrs)
Overview of Cells: Prokaryotic and eukaryotic cells, virus, viroids, mycoplasma, prions.
Plasma membrane: 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 and Nucleus (15 hrs)
Cytoskeleton: Structure and functions: microtubules, microfilaments and intermediate filaments.

UNIT 3: Endomembrane System, Mitochondria and Peroxisomes (15 hrs)
Endomembrane system: structure and functions: endoplasmic reticulum, golgi apparatus, lysosomes.

UNIT 4: Cell division and Cell Signalling (15 hrs)
Cell Division: Mitosis, meiosis, cell cycle and its regulation.
Cell Signaling: GPCR and role of second messenger (cAMP).
BZO-C4: Cell Biology

PRACTICALS

Credits: 2

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of various stages of meiosis.
3. Preparation of permanent slide to show the presence of barr body in human female blood cells/cheek cells.
4. Preparation of permanent slide to demonstrate:
   i DNA by feulgen reaction
   ii DNA and RNA by MGP
   iii Mucopolysaccharides by PAS reaction
   iv Proteins by mercurobromophenol blue/fast green

SUGGESTED READINGS

BZO-C5: DIVERSITY OF CHORDATES
THEORY

Total Lectures: 60
Credits: 4

Objectives:
- To impart knowledge about origin, taxonomic classification and structure and functions of chordates
- To make the students understand the basic characters, advancements and adaptations of different types of vertebrates.

UNIT 1: (15 hrs)
Introduction to Chordates
General characteristics and outline classification

Protochordata
General characteristics of hemichordata, urochordata and cephalochordata; study of larval forms in protochordates; retrogressive metamorphosis in urochordata

Origin of Chordata
Dipleurula concept and the echinoderm theory of origin of chordates
Advanced features of vertebrates over protochordata

UNIT 2: (15 hrs)
Agnatha
General characteristics and classification of cyclostomes up to class

Pisces
General characteristics of chondrichthyes and osteichthyes, classification up to order; migration, osmoregulation and parental care in fishes.

Amphibia
Origin of tetrapoda (evolution of terrestrial ectotherms); general characteristics and classification up to order; parental care in amphibians.

UNIT 3: (15 hrs)
Reptilia
General characteristics and classification up to order; affinities of sphenodon; (poison apparatus and biting mechanism in snakes).
Aves
General characteristics and classification up to order *Archaeopteryx*—a connecting link; principles and aerodynamics of flight, flight adaptations and migration in birds

**UNIT 4: (15 hrs)**

*Mammals*
General characters and classification up to order; affinities of prototheria; adaptive radiation with reference to locomotory appendages

*Zoogeography*
Zoogeographical realms, theories pertaining to distribution of animals, platetectonic and continental drift theory, distribution of vertebrates in different realms.
BZO-C5: DIVERSITY OF CHORDATES

PRACTICALS

Credits: 2

1. Protochordata
*Balanglossus, herdmania, branchiostoma*, colonial urochorddata sections of *balanglossus* through proboscis and branchiogenous regions, sections of *amphioxus* through pharyngeal, intestinal and caudal regions with the help of flow charts, slides or videos. Permanent slide of *herdmania* spicules

2. Agnatha
*Petromyzon, myxine*

3. Fishes
*Scoliodon, sphyra, pristis, torpedo, chimaera, mystus, heteropneustes, labelo, exocoetus, echeneis, anguilla, hippocampus, tetrodon/diodon, anabas, flat fish*

4. Amphibia
*Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra*

5. Reptilia
*Chelone, trionyx, hemidactylus, varanus, uromastix, chamaeleon, ophiosaurus, draco, bungarus, vepre, naja, hydrophis, zamenis, crocodynus*
Key for identification of poisonous and non-poisonous snakes

6. Aves
Study of six common birds from different orders, types of beaks and claws

7. Mammalia
*Sorex, bat (insectivorous and frugivorous), funambilus, loris, herpetes, erinaceous.*
demonstration of dissection of fowl head with the help of flow charts, slides or videos.
Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission)

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

SUGGESTED READINGS

BZO-C6: PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS (THEORY)

Total Lectures: 60          Credits: 4

Objectives:
- To enable the students know about all the physiological processes controlling the human body.
- To make the students understand the functions of hormones and their mechanism of action.

UNIT 1: (15 hrs)
Tissues
Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue

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

UNIT 2: (15 hrs)
Nervous System
Structure of neuron, resting membrane potential, origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; types of synapse, synaptic transmission and, neuromuscular junction; reflex action and its types - reflex arc; physiology of hearing and vision.

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

UNIT 3: (15hrs)
Reproductive System
Histology of testis and ovary; physiology of male and female reproduction; puberty, methods of contraception in male and female.

UNIT 4: (15hrs)
Endocrine System
Histology of endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action; classification of hormones; regulation of their secretion; mode of hormone action, signal transduction pathways for steroidal and non-steroidal hormones; hypothalamus (neuroendocrine gland) - principal nuclei involved in neuroendocrine control of anterior pituitary and endocrine system; placental hormones
BZO-C6: ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

PRACTICALS

Credits: 2

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

(*Subject to UGC guidelines)

SUGGESTED READINGS

BZO-C7: FUNDAMENTALS OF BIOCHEMISTRY
THEORY

Total Lectures: 60  
Credtis: 4

Objectives:
- To acquaint the students with the structure, chemical properties and biological significance of macromolecules of physiological importance.

UNIT 1: (16 hrs)
Carbohydrates
Structure and biological importance: monosaccharides, disaccharides, polysaccharides and glycoconjugates.

Lipids
Structure and significance: physiologically important saturated and unsaturated fatty acids, triacylglycerols, phospholipids, glycolipids, steroids.

UNIT 2: (14hrs)
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; denaturation; introduction to simple and conjugate proteins
Immunoglobulins: Basic structure, classes and function, antigenic determinants.

UNIT 3: (12hrs)
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, hyp- hyperchromaticity of DNA.

UNIT 4: (18hrs)
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.
BZO-C7: FUNDAMENTALS OF BIOCHEMISTRY
PRACTICAL

Credits: 2

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Action of salivary amylase under optimum conditions.
5. Demonstration of proteins separation by SDS-PAGE.

SUGGESTED READINGS

Semester IV

BZO-C8: COMPARATIVE ANATOMY OF VERTEBRATES
THEORY

Total Lectures: 60          Credits: 4

Objectives:
• To enable the students to develop an appreciation for the biodiversity of vertebrates.
• To impart knowledge about different forms of system in an organism which help in maintaining homeostasis.

UNIT 1: (16 hrs)
Integumentary System
Structure, functions and derivatives of integument.

Skeletal System
Overview of axial and appendicular skeleton, jaw suspensorium, visceral arches.

UNIT 2: (16 hrs)
Digestive System
Alimentary canal and associated glands, dentition.

Respiratory System
Skin, gills, lungs and air sacs; accessory respiratory organs.

UNIT 3: (14 hrs)
Circulatory System
General plan of circulation, evolution of heart and aortic arches.

Urinogenital System
Succession of kidney, evolution of urinogenital ducts, types of mammalian uteri.

UNIT 4: (14 hrs)
Nervous System
Comparative account of brain. autonomic nervous system, spinal cord, cranial nerves in mammals

Sense Organs
Classification of receptors
Brief account of visual and auditory receptors in man.
BZO-C8: COMPARATIVE ANATOMY OF VERTEBRATES
PRACTICALS

Credits: 2

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of frog, *varanus*, fowl, rabbit
3. Carapace and plastron of turtle /tortoise
4. Mammalian skulls: One herbivorous and one carnivorous animal
5. Demonstration of dissection of rat to study arterial and urinogenital system with the help of flow charts, slides or videos.
6. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted)
7. Project on skeletal modifications in vertebrates (may be included if dissection not permitted)

SUGGESTED READINGS

Total Lectures: 60          Credits: 4

Objectives:
  • To make the students aware about the different physiological processes of human body.

UNIT 1: Physiology of Digestion (15 hrs)
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 (15 hrs)
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 (15 hrs)
Structure of kidney and its functional UNIT; mechanism of urine formation; regulation of water balance; regulation of acid-base balance.

UNIT 4: Blood and Physiology of Heart (15 hrs)
Components of blood and their functions; structure and functions of haemoglobin haemostasis: blood clotting system, haemopoiesis 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. electrocardiogram, blood pressure and its regulation.
BZO-C9: ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS
PRACTICALS

Credits: 2

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer.*
3. Estimation of haemoglobin using Sahli’s haemoglobinometer*
4. Recording of blood pressure using a sphygmomanometer.
5. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum, liver, trachea, lung, kidney
6. Identification of blood cells in a blood smear. *
7. Differential leukocyte count. *

(*Subject to UGC guidelines)

SUGGESTED READINGS

BZO-C10: BIOCHEMISTRY OF METABOLIC PROCESSES
THEORY

Total Lectures: 60
Credtis: 4

Objectives:
- To provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis
- To enable students understand the molecular and cellular mechanism for metabolism of different macromolecules.

UNIT 1: Overview of Metabolism (15 hrs)
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: Protein Metabolism (15 hrs)
Catabolism of amino acids: Transamination, deamination, urea cycle; fate of C-skeleton of glucogenic and ketogenic amino acids.

UNIT 3: Carbohydrate Metabolism (15 hrs)
Sequence of reactions and regulation of glycolysis, citric acid cycle, phosphate pentose pathway, gluconeogenesis, glycogenolysis and glycogenesis.

UNIT 4: (15 hrs)
Lipid Metabolism
β-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; biosynthesis of palmitic acid.

Oxidative Phosphorylation
Malate-aspartate and glycerol-phosphate shuttle, mitochondrial respiratory chain, inhibitors and un-couplers of electron transport system.
BZO-C10: BIOCHEMISTRY OF METABOLIC PROCESSES
PRACTICALS

Credits: 2

1. Estimation of total protein in given solutions by Lowry’s method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
3. To study the enzymatic activity of trypsin and lipase.
4. To perform the acid and alkaline phosphatase assay from serum/ tissue.

SUGGESTED READINGS

GENERAL ELECTIVE

BZO-GE1: ANIMAL DIVERSITY
THEORY

Total Lectures: 60
Credits: 4

Objectives:

- To enable the students to develop an appreciation for the biodiversity of invertebrate and vertebrates.
- To impart knowledge about co-existence of different forms of living organisms ranging from unicellular to multicellular animals.

UNIT 1 (15 hrs)
Protista: General characters of protozoa; life cycle of plasmodium.
Porifera: General characters and canal system in porifera.
Radiata: General characters of cnidarians and polymorphism.
Aceolomates: General characters of helminthes; life cycle of *taenia solium*
Pseudocoelomates: General characters of nemethehelminthes; parasitic adaptations.

UNIT 2 (15 hrs)
Coelomate Protostomes: General characters of snelida; metamerism.
Arthropoda: General characters, social life in insects.
Mollusca: General characters of mollusca; pearl formation
Coelomate Deuterostomes: General characters of echinodermata, water vascular system in starfish.
Protochordata: Salient features.

UNIT 3 (15 hrs)
Pisces: Osmoregulation, migration of fishes.
Amphibia: General characters, adaptations for terrestrial life, parental care in amphibia.
Amniotes: Origin of reptiles, terrestrial adaptations in reptiles.

UNIT 4 (15 hrs)
Aves: The origin of birds; flight adaptations
Mammalia: Early evolution of mammals; primates; dentition in mammals.
BZO-GE1: ANIMAL DIVERSITY
PRACTICALS

Credits: 2

1. Study of following specimens:
   **Non Chordates:** Euglena, noctiluca, paramecium, sycon, physalia, tubipora, metridium, 
tenia, ascaris, nereis, earthworm, aphrodite, leech, peripatus, limulus, hermitcrab, daphnia, 
millipede, centipede, beetle, chiton, dentalium, octopus, asterias, and antedon.

   **Chordates:** Balanoglossus, amphioxus, petromyzon, pristis, hippocampus, laboe, 
ichthyophis/uraeotyphlus, salamander, rhacophorus draco, uromastix, naja, viper, model of 
archaeopteryx, any three common birds- (crow, duck, owl), squirrel and bat.

2. Study of following permanent slides:
   Cross section of sycon, sea anemone and Ascaris (male and female), water vascular system, 
tube feet, bipinnaria and pluteus larva.

3. Study of following permanent slides, charts and videos:
   • T. S. of earthworm passing through pharynx, gizzard, and typhlosolar intestine
   • Septal & pharyngeal nephridia of earthworm.
   • Unstained mounts of placoid, cycloid and ctenoid scales.

4. Demonstration of dissections with the help of flow charts, slides or videos.*
   • Digestive and nervous system of cockroach.
   • Urinogenital system of rat

*As per UGC guidelines.

SUGGESTED READINGS

BZO-GE2: AQUATIC BIOLOGY
THEORY

Total Lectures: 60
Credits: 4

Objectives:
• To enable the students understand the different fresh water habitats, the classification of waterbodies based on various physicochemical and biological parameters and the importance of fishery science.

UNIT 1: Aquatic Biomes (15 hrs)
Aquatic Biomes: brief introduction of the aquatic biomes: freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

UNIT 2: Freshwater Biology (15 hrs)
Lakes: origin and classification, lake as an ecosystem, lake morphometry, physico–chemical characteristics: light, temperature, thermal stratification, dissolved solids, carbonate, bicarbonates, phosphates and nitrates, turbidity; dissolved gases (oxygen, carbon dioxide), nutrient cycles in lakes-nitrogen, sulphur and phosphorous.
Streams: different stages of stream development, physico-chemical environment, adaptation of hill-stream fishes.

UNIT 3: Marine Biology (15 hrs)

UNIT 4: Management of Aquatic Resources (15 hrs)
Management of Aquatic Resources: causes of pollution; agricultural, industrial, sewage, thermal and oil spills, eutrophication, management and conservation (legislations), sewage treatment; water quality assessment- BOD and COD.
BZO-GE2: AQUATIC BIOLOGY
PRACTICALS

Credits: 2

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

SUGGESTED READINGS

BZO-GE3: IMMUNOLOGY
THEORY

Total Lectures :60  
Credits :4

Objectives:
- To acquaint the students with the basic concepts of immunology and the immune effector mechanisms. To make the student understand the role of immunity in controlling the pathogenic infection.

UNIT 1: Overview of Immune System, Innate and Adaptive Immunity. (15 hrs)
Historical perspective of immunology, early theories of immunology, 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. (15 hrs)
Antigenicity and immunogenicity, immunogens, adjuvants and haptens, factors influencing immunogenicity, B and T-Cell epitopes.
Structure and functions of different classes of immunoglobulins, antigen-antibody interactions, immunoassays (ELISA and RIA), polyclonal sera.

UNIT 3: Major Histocompatibility Complex and Cytokines. (15 hrs)
Structure and functions of MHC molecules. endogenous and exogenous pathways of antigen processing and presentation.
Properties and functions of cytokines, therapeutics cytokines.
Immune dysfunctions (brief account of autoimmunity with reference to rheumatoid arthritis and tolerance, AIDS).

UNIT 4: Complement System, Hypersensitivity and Vaccines. (15 hrs)
Components and pathways of complement activation.
Gell and Coombs’ classification and brief description of various types of hypersensitivities.
Various types of vaccines.
Hybridoma technology: monoclonal antibodies in therapeutics and diagnosis.
BZO-GE3: IMMUNOLOGY
PRACTICALS

Credits: 2

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

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

SUGGESTED READINGS

BZO-GE4: HUMAN PHYSIOLOGY
THEORY

Total Lectures: 60                                                                                       Credits: 4

Objectives:
• To enable the students know about all the physiological processes going on in the human body.
• To make the students understand the functions of hormones and their mechanism of action.

UNIT 1: Digestion and Absorption of Food. (15 hrs)
Structure and function of digestive glands; digestion and absorption of carbohydrates, fats and proteins; nervous and hormonal control of digestion (in brief).

UNIT 2: Respiratory Physiology and Renal Physiology. (15 hrs)
Ventilation, external and internal respiration, transport of oxygen and carbon dioxide in blood, factors affecting transport of gases.
Functional anatomy of kidney, mechanism and regulation of urine formation.

UNIT 3: Functioning of Excitable Tissue (Nerve and Muscle) and Cardiovascular Physiology. (15 hrs)
Structure of neuron, propagation of nerve impulse (myelinated and non-myelinated nerve fibre); structure of skeletal muscle, mechanism of muscle contraction (sliding filament theory); neuromuscular junction.
Structure of heart, coordination of heartbeat, cardiac cycle, ecg.

UNIT 4: Endocrine and Reproductive Physiology (15 hrs)
Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), brief account of spermatogenesis and oogenesis, menstrual cycle.
BZO-GE4: HUMAN PHYSIOLOGY
PRACTICALS

Credits: 2

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

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

SUGGESTED READINGS

BZO-GE5: INSECT VECTORS AND DISEASES
THEORY

Objective:
- To acquaint the students with the general and identifying features of insects.
- To introduce the student to the important insect vectors causing diseases in animals and men.

UNIT 1: (15 hrs)
Introduction to insects- general features of insects, morphological features, head – eyes, types of antennae, mouth parts w.r.t. feeding habits
Insects as Vectors- classification of insects up to orders, detailed features of orders with insects as vectors – diptera, siphonaptera, siphunculata, hemiptera

UNIT 2: (15 hrs)
Concept of Vectors- brief introduction of carrier and vectors (mechanical and biological vector), reservoirs, host-vector relationship, vectorial capacity, adaptations as vectors, host specificity
Dipterans as important insect vectors – mosquitoes, sand fly, houseflies
Study of house fly as important mechanical vector, myiasis, control of house fly
Fleas as important insect vectors
Human louse (head, body and pubic louse) as important insect vectors
Bugs as insect vectors; blood-sucking bugs

UNIT 3: Dipteran as Disease Vectors: (15 hrs)
Study of mosquito-borne diseases – malaria, dengue, chikungunya, viral encephalitis, filariasis; control of mosquitoes
Study of sand fly-borne diseases – visceral leishmaniasis, cutaneous leishmaniasis, phlebotomus fever; control of sand fly

UNIT 4: (15 hrs)
Siphonaptera as Disease Vectors
Host-specificity of fleas, study of flea-borne diseases – plague, typhus fever; control of fleas

Siphunculata as Disease Vectors
Study of louse-borne diseases – typhus fever, relapsing fever, trench fever, vagabond’s disease, phthiriasis; control of human louse

Hemiptera as Disease Vectors
Chagas disease, bed bugs as mechanical vectors, control and prevention measures as mechanical vectors, control and prevention measures
1. Study of different kinds of mouth parts of insects with the help of flow charts, slides or videos.
2. Study of following insect vectors through permanent slides/photographs: *aedes*, *culex*, *anopheles*, *pediculus humanus capitis*, *pediculus humanus corporis*, *phithirus pubis*, *xenopsylla cheopis*, *cimex lectularius*, *phlebotomus argentipes*, *musca domestica*, through permanent slides/photographs
3. Study of different diseases transmitted by above insect vectors

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

SUGGESTED READINGS

BZO-GE6: EVOLUTION AND PALEONTOLOGY

THEORY

Total Lectures: 60                                                                                       Credits: 4

Objectives:

- To acquaint the students with origin and evolution of life and evidences those support these theories.
- To make the students understand the importance of Palaeontology with special reference to the fossils, dating of fossils and geological time scale.
- To make the students understand origin and evolution of different vertebrates.

UNIT 1: Origin of Life and Evidences (15 hrs)

Origin of bio molecules (DNA, RNA) and its scientific evidence, origin of prokaryote and eukaryote cells, origin of unicellularity and multicellularity.

Evidences from zoogeography, taxonomy, comparative morphology and anatomy, palaeontology, comparative physiology, embryology, genetics, molecular biology and biochemistry.

UNIT 2: Evolutionary Theories (15 hrs)

Lamarckism and neo-lamarckism; darwinism and neo-darwinism (synthetic theory); weismann’s theory; mutation theory; mutation, variations and selection; modern concept of interpretation of evolution and future of evolutionary process.

UNIT 3: Introduction to Palaeontology (15 hrs)

History, stratigraphy: principles, importance, successive stratigraphic steps; fossils: importance and dating of fossils; geologic time scale: general account of palaeo-meso-and cenozoic eras with a mention of important fossil groups in different eras, periods and epochs.

UNIT 4: Origin of Vertebrates (15 hrs)

Origin of pisces, amphibia, reptilia, aves and mammalia. ancestry of man, horse, camel and elephant.
BZO-GE6: EVOLUTION AND PALEONTOLOGY PRACTICALS

1. Study of some charts relevant to Palaeontology.
2. Study of models of dinosaurs.
4. Visit to fossil park, Saketi, Kala Amb (H.P.)
5. Visit to Museum of Department of Anthropology, P.U., Chandigarh.
7. Study of some charts relevant to Palaeontology.

SUGGESTED READINGS

SKILL ENHANCEMENT COURSES

SEC 1-APICULTURE

Credits: 2

UNIT 1: Biology of Bees (4 hrs)
History, classification and biology of honey bees
Social organization of bee colony

UNIT 2: Rearing of Bees (10 hrs)
Artificial bee rearing (apiary), beehives – newton and langstroth
Bee pasturage
Selection of bee species for apiculture
Bee keeping equipment
Methods of extraction of honey (indigenous and modern)

UNIT 3: Diseases and Enemies (5 hrs)
Bee diseases and enemies
Control and preventive measures

UNIT 4: (6 hrs)
Bee Economy
Products of apiculture industry and its uses (honey, bees wax, propolis), pollen etc.

Entrepreneurship in Apiculture
Bee keeping Industry – recent efforts, modern methods in employing artificial, beehives for cross pollination in horticultural gardens

SUGGESTED READINGS

UNIT1: Introduction to Aquarium Fish Keeping (6 hrs)
Aquarium fish trade: present status; potential; major exporting and importing countries; species-wise contribution of freshwater and marine fishes; contribution of culture and capture; marketing strategies; anesthetics, exotic and endemic species of aquarium fishes.

UNIT 2: Biology of Aquarium Fishes (6 hrs)
Breeding techniques: reproductive biology, captive breeding and rearing of freshwater, brackish water and marine ornamental fishes; identifying features of common aquarium fishes such as guppy, molly, sword tail, gold fish, and angel fish.

UNIT 3: Food and feeding of Aquarium fishes (6 hrs)
Aquarium keeping: design and construction of tanks; heating, lighting, aeration and filtration arrangements; decorations used; common aquarium plants and their propagation; feed, health and water quality management; prophylaxis; quarantine; use of live fish feed organisms; preparation and composition of formulated fish feeds.

UNIT 4: Value Addition and Fish Transportation (6 hrs)
Value addition: colour enhancement; genetic manipulation and production of new strains; hybrids
Live fish transport: fish handling, packing and forwarding techniques; budget for setting up an aquarium

SUGGESTED READINGS
SEC 3-MEDICAL DIAGNOSTICS

UNIT 1: (8 hrs)
Introduction to Medical Diagnostics and its Importance

Diagnostic Methods Used for Urine Analysis
Urine analysis: physical characteristics; abnormal constituents.

UNIT 2: Diagnostics Methods Used for Analysis of Blood (10 hrs)
Blood composition, preparation of blood smear and differential leucocyte count (d.l.c) using leishman's stain, platelet count using haemocytometer, erythrocyte sedimentary rate (e.s.r), packed cell volume (p.c.v.)

UNIT 3: (8 hrs)
Non-infectious Diseases
Causes, types, symptoms, complications, diagnosis and prevention of diabetes (type i and type ii), hypertension (primary and secondary), testing of blood glucose using glucometer/kit.

UNIT 4: (6 hrs)
Infectious diseases
Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis.

Tumours
Types (benign/malignant), detection and metastasis; medical imaging: x-ray of bone fracture, pet, mri and ct scan (using photographs).

SUGGESTED READINGS

SEC 4- RESEARCH METHODOLOGY

Credits: 2

UNIT 1: Foundations of Research (5 hrs)
Meaning, objectives, motivation: research methods vs methodology, types of research: analytical vs descriptive, quantitative vs qualitative, basic vs applied

UNIT 2: Research Design (8 hrs)
Need for research design: features of good design, important concepts related to good design-observation and facts, prediction and explanation, development of models. developing a research plan: problem identification, experimentation, determining experimental and sample designs

UNIT 3: Data Collection, Analysis and Report Writing (12 hrs)
Observation and collection of data-methods of data collection- sampling methods, data processing and analysis strategies, technical reports and thesis writing, preparation of tables and bibliography. data presentation using digital technology

UNIT 4: Ethical Issues (5 hrs)
Intellectual property rights, commercialization, copy right, royalty, patent law, plagiarism, citation, acknowledgement

SUGGESTED READINGS