

M.Sc. Zoology 2018-2020
Choice Based Credit System
Course Structure and Scheme of Examination

SEMESTER I

Code	Course	C/E/S	L	T	P	Credit	Marks
CBCSZ-101	Non-Chordata	Core	3		0	3	100
CBCSZ -102	Chordata	Core	3		0	3	100
CBCSZ -103	Cytogenetics and Genetics	Core	3		0	3	100
CBCSZ -104	Cell Structure & Function	Core	3		0	3	100
CBCSZ -105	Practical	Core	0		3	3	100
CBCSZ -106	Practical	Core	0		3	3	100
CBCSZ -107	Assignment/Skill development/Project work	Core				1	100
CBCSZ -108	Seminar	Core				1	100
CBCSZ -109	Comprehensive viva-voce exam	Virtual credit				4	100
						24	900

Total Credit Value: #24

SEMESTER II

Code	Course	C/E/S	L	T	P	Credit	Marks
CBCSZ -201	Biochemistry	Core	3		0	3	100
CBCSZ -202	A. Biochemical & Molecular Techniques and B. Biostatistics & Bioinformatics	Core	3		0	3	100
CBCSZ -203	Immunology	Core	3		0	3	100
CBCSZ -204	Histology and Molecular Histochemistry	Core	3		0	3	100
CBCSZ -205	Practical	Core	0		3	3	100
CBCSZ -206	Practical	Core	0		3	3	100
CBCSZ -207	Assignment/Skill development/Project work	Core				1	100
CBCSZ -208	Seminar-II	Core				1	100
CBCSZ -209	Comprehensive viva-voce exam	Virtual credit				4	100
						24	900

Total Credit Values: #24

SEMESTER III

Code	Course	C/E/S	L	T	P	Credit	Marks
CBCSZ -301	Developmental Biology	Core	3		0	3	100
CBCSZ -302	Mammalian Physiology & Endocrinology	Core	3		0	3	100
CBCSZ -303	Major Elective-I	Elective C/	3		0	3	100
CBCSZ -304	Major Elective-II	Elective C/	3		0	3	100
CBCSZ -305	Practical	Core			3	3	100
CBCSZ -306	Practical	Elective C			3	3	100
CBCSZ -307	Assignment/Skill development/ Project work	Elective C/G	1			1	100
CBCSZ -308	Seminar-III	Elective C/G				1	100
CBCSZ -309	Comprehensive viva-voce exam	Virtual credit				4	100
						24	900

Total Credit Values: #24**SEMESTER IV**

Code	Course	C/E/S	L	T	P	Credit	Marks
CBCSZ -401	Taxonomy and Evolution	Core	3		0	3	100
CBCSZ -402	A. Animal Ecology and B. Animal Behavior	Core	3		0	3	100
CBCSZ -403	Major Elective-III	Elective C	3		0	3	100
CBCSZ -404	Major Elective-IV	Elective C	3		0	3	100
CBCSZ -405	Practical	Core			3	3	100
CBCSZ -406	Practical	Elective C			3	3	100
CBCSZ -407	Assignment/Skill development/ Project work	Elective C/G	1			1	100
CBCSZ -408	Seminar-IV	Elective C/G				1	100
CBCSZ -409	Comprehensive viva-voce exam	Virtual credit				4	100
						24	900

Major Electives

(Details will be provided with the syllabus for Sem. III & IV)

A: Aquatic Biology and Aquaculture

SEMESTER III

Code	Course	C/E/S	L	T	P	Credit	Marks
303	Aquatic Ecology & Resources		3		0	3	100
304	Fish Biology & Physiology		3		0	3	100
306	Aquatic Biology & Fish Biology (Practical)				3	3	100

SEMESTER IV

Code	Course	C/E/S	L	T	P	Credit	Marks
403	Fisheries & Pisciculture		3		0	3	100
404	Aquaculture		3		0	3	100
406	Fisheries, Pisciculture & Aquaculture (Practical)				3	3	100

B: CELLULAR NEUROBIOLOGY AND HUMAN GENETICS

SEMESTER III

Code	Course	C/E/S	L	T	P	Credit	Marks
303	Cellular Neurobiology		3		0	3	100
304	Methods in molecular genetic analysis		3		0	3	100
306	Methods in cell and molecular biology				3	3	100

SEMESTER IV

Code	Course	C/E/S	L	T	P	Credit	Marks
403	Cellular basis of brain function		3		0	3	100
404	Human genetics and Cancer		3		0	3	100
406	Neurobiology and Human genetics				3	3	100

C: Endocrinology

SEMESTER III

Code	Course	C/E/S	L	T	P	Credit	Marks
303	Comparative Endocrinology		3		0	3	100
304	Endocrine Physiology		3		0	3	100
306	General & Comparative Endocrinology & Endocrine Physiology (Practical)				3	3	100

SEMESTER IV

Code	Course	C/E/S	L	T	P	Credit	Marks
403	Male Reproductive Endocrinology		3		0	3	100
404	Female Reproductive Endocrinology		3		0	3	100
406	Reproductive Endocrinology (Practical)				3	3	100

D: Entomology**SEMESTER III**

Code	Course	C/E/S	L	T	P	Credit	Marks
303	General Entomology & Insect Morphology		3		0	3	100
304	Insect Anatomy & Physiology		3		0	3	100
306	General Entomology (Practical)				3	3	100

SEMESTER IV

Code	Course	C/E/S	L	T	P	Credit	Marks
403	Insect Taxonomy, Ecology & Development		3		0	3	100
404	Applied Entomology		3		0	3	100
406	Insect Taxonomy, Ecology & Development & Applied Entomology (Practical)				3	3	100

SEMESTER I
CBCSZ- 101: NON CHORDATA
(Credits 3)

(No. of classes of 60 min each.)

UNIT I

- 1. Protozoa (2)
- 1.1 Structure and reproduction (1)
- 1.2 Theories of the origin of metazoans (1)
- 2. Porifera: Aquaferous system (1)
- 3. Cnidaria: Polymorphism in Siphonophora (1)
- 4. Annelida (2)
- 4.1 Adaptive radiation in polychaetes (1)
- 4.2 Larval forms (e.g. Trochophore) (1)

UNIT II

- 5. Arthropoda (2)
- 5.1 Evolutionary significance of Trilobites
- 5.2 Crustacean larval forms and their significance
- 6. Insecta (7)
- 6.1. Importance and taxonomic richness of insects
- 6.2. Internal anatomy and physiology
- 6.2.1 Nervous system
- 6.2.2 Endocrine system and function of hormones
- 6.2.3 Circulatory system: heart and haemolymph
- 6.2.4 Respiratory system: Aerial respiration and Aquatic respiration
- 6.2.5 Digestive system: Structure of gut and Digestion of food
- 6.2.6 Excretory system and waste disposal: Malpighian tubules and Nitrogen excretion

UNIT III

- 6.2.7 Reproduction in Insects: Female and male systems; Oogenesis and Spermatogenesis (1)
- 6.3. External anatomy of Insects (3)
- 6.3.1 Segmentation and tagmosis in insects
- 6.3.2 Integument: structure and functions of cuticle, sclerotization
- 6.4. Sensory system of Insects (2)
- 6.4.1 Tactile receptors, mechanoreceptors, chemoreceptors and proprioceptors
- 6.4.2 Compound eye
- 7. Insects as friends and foes (1)
- 8. General methods of insect pest management (1)

UNIT IV

- 9. Mollusca (2)
- 9.1 Larval forms
- 9.2 Nervous system
- 10. Echinodermata (2)
- 10.1 Larval forms and their significance
- 10.2 Blood vascular system
- 11. Salient features and affinities of (6)
- 11.1 Placozoa

- 11.2 Mesozoa
- 11.3 Rotifera
- 11.4 Phoronida
- 11.5 Sipunculata
- 11.6 Hemichordata

CBCSZ-102: Chordata

(Credits 3)

(No. of classes of 60 min each.)

UNIT I

1. Characteristic features and affinities of (6)
 - 1.1 Protochordata
 - 1.1.1. Urochordata
 - 1.1.2. Cephalochordata
 - 1.2. Cyclostomata
2. Origin of the following: (6)
 - 2.1 Fish
 - 2.2 Amphibian
 - 2.3 Reptile
 - 2.4 Bird
 - 2.5 Mammal

UNIT II

3. Adaptive radiation in vertebrates (5)
 - 3.1 Aquatic
 - 3.2 Terrestrial
 - 3.3 Aerial
 - 3.4 Arboreal
 - 3.5 Fossorial
4. Parental care in amphibians (2)
5. Skull in reptiles (1)
6. Migration in birds (1)
7. Flightless birds (1)

UNIT III

8. Comparative anatomy (9)
 - 8.1 Respiratory system: Characters of respiratory tissue, external and internal respiration,
 - 8.2 Comparative accounts of respiratory organs
 - 8.3 Evolution of heart
 - 8.4 Evolution of aortic arches and portal systems
 - 8.5 Comparative account of jaw suspensorium and vertebral column

UNIT IV

9. Comparative anatomy
 - 9.1 Comparative account of limbs and girdles (2)
 - 9.2 Evolution of urinogenital system in vertebrates (2)
 - 9.3 Comparative account of organs of olfaction and taste (2)
 - 9.4 Comparative anatomy of brain and spinal cord (CNS) (2)
 - 9.5 Comparative account of peripheral and autonomic nervous system (2)
 - 9.6 Comparative account of lateral line system (1)
 - 9.7 Comparative account of simple receptor (Tactile receptors) (2)

Books Recommended

1. Barnes: Invertebrate Zoology (4thed 1980, Holt Saunders International)
2. Barnes: The Invertebrates – A Synthesis (3rded 2001, Blackwell)
3. Hunter : Life of Invertebrates (1979, Collier Macmillan)
4. Marshall: Parker &Hashwell Textbook of Zoology, Vol I (7thed 1972, Macmillan)
5. Moore : An Introduction to the Invertebrates (2001, Cambridge University Press)
6. Harvey *et.al* : The Vertebrate Life (2006)
7. Colbert *et.al* : Colbert’s Evolution of the Vertebrates : A History of the Backboned Animals through time (5thed, 2002, Willey-Liss)
8. Hildebrand : Analysis of Vertebrate Structure (4thed, 1995, John Willey)
9. Jordan &Verma : Chordate Zoology (1998, S. Chand)
10. Kotpal: The Birds (4thed, 1999, Rastogi Publications)
11. McFarland *et.al* : Vertebrate Life (1979, Macmillan Publishing)
12. Parker &Hashwell : Textbook of Zoology, Vol. II (1978, ELBS)
13. Romer& Parsons : The Vertebrate Body (6thed 1986, CBS Publishing Japan)
14. Sinha, Adhikari&Ganguli : Biology of Animals Vol. II (1988, New Central Book Agency)
15. Young : The life of Vertebrates (3rded 2006, ELBS/Oxford)
16. Singh: Advances in Fish Research, Vol. I, II and III (Fisheries and Fish Biology: Ed DattaMunshi) (1993, 1997and 2004, Narendra Publishing House Delhi)

CBCSZ103: CYTOGENETICS AND GENETICS

(Credits 3)

(No. of classes of 60 min each.)

UNIT I

- 1. Eukaryotic chromatin structure and chromosome organization (7)**
 - 1.1 Classes of DNA
 - 1.2 Chromosomal proteins: histones, non-histone proteins and scaffold/matrix proteins
 - 1.3 Nuclear matrix and organization of interphase nucleus
 - 1.4 Centromere, kinetochore and telomere
 - 1.5 Metaphase chromosome banding
- 2. Giant chromosome: Polytene chromosome & Lampbrush chromosome (2)**
- 3. Molecular mechanism of Sex determination in drosophila and mammals (human/mice) (2)**
- 4. Mechanism of dosage compensation in (2)**
 - 4.1 Drosophila
 - 4.2 Mammals (Human/mice)

UNIT II

- 5. Humancytogenetics (7)**
 - 5.1 Karyotype and nomenclature of metaphase chromosome bands
 - 5.2 Chromosome anomalies and diseases
 - 5.2.1 Types of chromosomal anomalies
 - 5.2.2 Common syndromes caused by aneuploidy, mosaicism, deletion and duplication
 - 5.2.3 Chromosomal anomalies in malignancy (chronic myeloid leukemia and retinoblastoma)
 - 5.2.4 Fragile site and X-linked mental retardation
 - 5.2.5 Mechanism and methods of chromosomal banding

UNIT III

- 6. Mendel's laws and their chromosomal basis (2)**
- 7. Extensions of Mendelism (7)**
 - 7.1 Dominance relationships
 - 7.2 Epistasis
 - 7.3 Pleiotropy
 - 7.4 Lethal gene
 - 7.5 Multiple allelism
- 7.6 Test of allelism (Complementation)
- 8. Methods of gene mapping (3)**
 - 8.1 3-point test cross in *Drosophila*
 - 8.2 Gene mapping in bacteria by transformation and conjugation
- 9. Quantitative inheritance: Concept of polygene & polygenic inheritance (2)**
- 10. Cytoplasmic inheritance: Paramoecium, yeast, snail and plant (chloroplast)(3)**

UNIT IV

- 11. Gene mutation and DNA repair (3)**
 - 11.1 Types of gene mutations
 - 11.2 DNA damage and repair
- 12. Nature of the gene and its function (6)**

- 12.1 Fine structure of gene (*rII* locus)
- 12.2 Regulation of gene activity in *lac* and *tryptophan* operon of *E.coli*
- 12.3 Organization of a typical eukaryotic gene; basic understanding on Transcription regulation (TF & RNA polymerases)
- 12.4 Non-coding genes
- 13. Mitochondrial DNA: Organization & properties** (1)

Books Recommended

1. Alberts et al: Molecular Biology of the Cell (2008, Garland)
2. Bostock & Sumner: Eukaryotic Chromosome (1987, North-Holland)
3. Cassimeris et al: Lewin's Cells (2011, Jones Bartlett)
4. Gardner et al: Principles of Genetics (2006, John Wiley)
5. Griffith et al: Modern Genetic Analysis (2008, Freeman)
6. Hartl & Jones: Essential Genetics: A Genomic perspective (2009, Jones & Bartlett)
7. Karp: Cell and Molecular Biology (2010, John Wiley & Sons)
8. Krebs et al: Lewin's Genes X (2011, Jones & Bartlett)
9. Lodish et al: Molecular Cell Biology (2008, Freeman)
10. Pierce: Genetics – A Conceptual Approach (2012, Freeman)
11. Russell: Genetics (2010, Benjamin Cummings)
12. Snustad & Simmons: Principles of Genetics (2012, John Wiley)

CBCSZ -104: Cell Structure & Function

(No. of classes of 60 min each.)

UNIT-I

1. Plasma Membrane: (3)
 - 1.1 Molecular organization
 - 1.2 Transport across membrane
2. Mechanisms of Endocytosis and Exocytosis. (1)
3. Endomembrane system: Ultrastructure of EPR & transport through EPR (2)
4. Endomembrane system: Ultrastructural organization of Golgi complex & Transport through GC. (2)
5. Mitochondria: (2)
 - 5.1 Ultrastructure
 - 5.2 Mitochondrial transport
 - 5.3 Chemiosmotic theory and respiratory chain complexes

UNIT-II

6. Ultrastructure of nucleus & nucleolus (1)
7. Mechanisms of intracellular digestion: Structure & functions of Lysosomes. (1)
8. Structure and functions of Peroxisomes (1)
9. Structure and biosynthesis of Ribosomes (1)
10. Signaling (4)
 - 10.1 Intracellular receptor and cell surface receptors
 - 10.2 Signaling via G-protein linked receptors (PKA, PKC, CaM kinase)
 - 10.3 Enzyme linked receptor signaling (Growth factor receptor signaling; JACK-STAT pathway)
 - 10.4 Network and cross-talk between different signal mechanisms
 - 10.5 Role of NO & CO in cell signaling.

UNIT-III

11. Cytoskeletons: (3)
 - 11.1 Microfilaments: Structural organization. Cell motility and cell shape
 - 11.2 Intermediate filaments
12. Microtubule: Ultra structure and functional organization (2)
13. Structure and functions of cilia, flagella, and centriole (1)
14. Cell cycle and its regulation (4)
 - 14.1 Overview of the Cell cycle
 - 14.2 Cell cycle control system
 - 14.3 Control of cell division and cell growth

UNIT-IV

15. Mitotic Cell Division: Molecular mechanisms (3)
 - 15.1 Mitotic spindle and arrangement of chromosomes on equator
 - 15.2 Regulation of exit from metaphase
 - 15.3 Chromosome movement at anaphase
16. Meiotic Cell division (2)
 - 16.1 Overview of the process
 - 16.2 Meiosis specific cellular changes: Molecular & Biochemical
 - 16.3 Genetic consequences of meiosis
 - 16.4 Molecular mechanism of meiotic recombination
17. Programmed cell death and Senescence: (4)
 - 17.1 Definition and General Characteristics; Necrosis & PCD

- 17.2 Morphological and Biochemical changes
- 17.3 Molecular pathways of PCD
- 17.4 Inhibitors of PCD and survival factors
- 18. Cell-Cell Interaction (3)
- 18.1. Cell adhesions
- 18.2. Cell junctions (Occluding, Anchoring & Gap junctions)
- 18.3. Extracellular matrix: Organization & Functions; Integrins

Recommended Books

1. Molecular Biology of the Cell, 4th Ed., Alberts et al, Garland, 2002
2. Molecular Cell Biology, 6th Ed., Lodish et al, Freeman & Co. 2008
3. Cell and Molecular Biology, Karp, Wiley, 2002
4. Developmental Biology, 8th Ed., Gilbert, Sinauer, 2006
5. Essential Cell Biology Alberts et al Garland 1998
6. Cell and Molecular Biology, 8th Ed., De Robertis, Lea &Febiger, 1987.
7. The Cell, Cooper, ASM Press, 2004.
8. Molecules of Death, 2nd Ed., Waring et al, ICP, 2007
9. Principles of Anatomy and Physiology, 11th Ed., Tortora&Derrickson, Wiley, 2006.

LABORATORY EXERCISES
CBCSZ 105: NON CHORDATA & CHORDATA
(Credits 3)

Part A: Non Chordata&Chordata (Credit 1.5)

Non Chordata

1. Preparation of permanent slides
 - 1.1 Protozoa: *Paramecium* (whole mount) and demonstration of food vacuoles, etc.
 - 1.2 Cnidaria: *Bougainvillea*, *Sertularia*, etc.
 - 1.3 Arthropoda: Cyclops, Megalopa/Zoea, spiracles of cockroach, etc.
 - 1.4 Mollusca: Glochidium larva, etc.
 - 1.5 Echinodermata: Spheredium, pedicellaria, tubefeet
 - 1.6 Helminths
 - 1.7 Annelids

2. Dissections

- 2.1 Arthropoda: Salivary glands of cockroach, etc.
- 2.2 Mollusca: nervous system of *Mytilus* and *Aplysia/Sepia*

3. Study of museum specimens

- 3.1 Porifera
- 3.2 Cnidaria
- 3.3 Helminth
- 3.4 Annelida
- 3.5 Arthropoda
- 3.6 Mollusca
- 3.7 Echinodermata
- 3.8 Pisces
- 3.9 Amphibians
- 4.0 Reptilia
- 4.1 Aves
- 4.2 Mammalia

Insects

4. Study of external morphology of cockroach
5. Internal anatomy of cockroach
 - 5.1 Alimentary canal
 - 5.2 Salivary apparatus: dissection and *in toto* stained preparation
6. Dissection of Nervous system of Prawn/Pila/Sepia/Loligo/Squilla
7. Dissection and mounting of prothoracic gland/Sting apparatus/ Pollen Basket of honey bee.
8. Dissection of male and female reproductive systems of cockroach
9. Study of external morphology of honey bee and dissection of sting apparatus
10. Study of following using permanent slides/specimens: L. S. of teleotrophic and polytrophic ovarioles, T. S. of testis, and brain showing median neuro secretory cells (MNSC), whole mount of head of louse, CC & CA, and *Chironomous* larva

Chordata

11. Study of external features of *Branchiostoma* and permanent preparation of its oral hood, velum and pharyngeal wall

12. Study of whole mount preparations of following proto-chordates
 - 12.1 *Doliolum*, *Pyrosoma*, *Salpa* and *Oikopleura*
 - 12.2 T.S. through pharynx, gonads and post anal region of *Branchiostoma*
 - 12.3 T.S. and L.S. through proboscis of *Balanoglossus*
13. Permanent preparation of spicules/blood ampullae of *Herdmania*
14. Fossorial adaptation and urino-genital system of rat
15. Study of adaptive features of following:
 - 15.1 Amphibians
 - 15.2 Reptiles
 - 15.3 Birds
 - 15.4 Mammals
16. Study of migratory and residential birds.

Fish Biology

17. Classification of the following locally available fishes using key
 - 17.1 Carps: *Catlacatla*; *Labeorohita*, *Cirrhinamrigala*
 - 17.2 Catfishes: *Hetero pneustesfossilis*, *Clariasbatrachus*
18. Study of larvivorous fishes/fishes having electric organs, venomous organs and air breathing organs through museum specimens
19. Identification of poisonous and nonpoisonous snakes.
20. Study of disarticulated skeleton of vertebrates.
21. Study and mounting of chordate material: fish/birds/reptiles
22. Study of perching muscles in birds

Scheme

Q.1 Major Dissection	(8)
Q.2 Minor Dissection/ Mounting	(6)
Q.3 Mounting and preparation of vertebrate or invertebrate material	(6)
Q.4 Exercise on: 2x5	(10)
(a) Poisonous/non-poisonous snakes	
(b) Perching mechanism in birds	
Q.5 Spotting (Museum specimen, slides, larvivorous fishes, venomous, electric, disarticulated skeleton-(8x2)	(16)
Q.6 Viva voce	(8)
Q.7 Practical record	(6)

Total marks 60

CBCSZ 106: CYTOGENETICS, GENETICS AND CELL STRUCTURE AND FUNCTION

(Credits 3)

Cytogenetics

1. Study of mitosis in onion root tip by squash method.
2. Study of meiosis in grasshopper testes and
3. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila/ Chironomous* larvae
4. Preparation of human karyotype
5. Study of sex chromatin in human female from buccal epithelial/hair bud cells
6. Study of permanent slides for the following:
 - 6.1 Inversions in polytene chromosomes of *Drosophila*
 - 6.2 G-banded and C-banded metaphase chromosomes

Genetics

7. Culturing *E coli* on solid and liquid media
8. Handling of *Drosophila* and study its life cycle
9. Examination of wild type (males and females) and mutant *Drosophila melanogaster*
10. Sex linked inheritance in *Drosophila melanogaster*
11. Monohybrid and di-hybrid crosses in *Drosophila melanogaster*,
12. Genetic distance calculations in linkage and crossing over experiment and 3-point test cross.

Cell Structure & Function

1. Practical based on membrane transport
2. Study of electron micrograph of cell organelles (Nucleus, Nucleolus, Ribosome, Endoplasmic reticulum, Mitochondria, Chloroplast, Microtubules, Microfilament)
3. Preparation of blood smear and identification of different type of cells.
4. Cell viability assay (Triple blue exclusion method).

Scheme

- Q.1 (a) Experiment on meiotic or mitotic preparation / squash preparation of material provided to show polytene chromosomes /sex chromatin (6)
- (b) Preparation of human karyotype/G-banded and C-banded metaphase chromosome (6)
- Q.2 Monohybrid/di-hybrid/ sex linkage/3-point test crosses in *Drosophila melanogaster* (6)
- Q.3 Slide preparation of blood smear to identify different type of cells. (6)
- Q.4 Cell viability assay/Practical based on membrane transport (6)
- Q.5 Spotting (8) (16)
- Q.6 Viva voce (8)
- Q.7 Practical record (6)

Total marks 60

SEMESTER II
CBCSZ 201: BIOCHEMISTRY
(Credits 3)

(No. of classes of 60 mins each)

UNIT-I

1. Bioenergetics (4)
 - 1.1. Second law of thermodynamics
 - 1.2. Free energy
 - 1.3. High-energy compounds
 - 1.4. Water
 - 1.5 Oxidative phosphorylation
2. Carbohydrates (3)
 - 2.1. Introduction
 - 2.2. Mucopolysaccharides and related disorders
 - 2.3. Glycolysis
 - 2.4. Krebs cycle
3. Carbohydrate metabolism (3)
 - 3.1. Gluconeogenesis
 - 3.2. Pentose phosphate pathway
 - 3.3. Glycogenesis and glycogenolysis.
4. Disorders of glycogen metabolism (1)
5. Structure and function of water- and lipid- soluble vitamins (2)

UNIT-II

6. Lipids (3)
 - 6.1. Fatty acids: synthesis and oxidation of fatty acid
 - 6.2. Ketogenesis
 - 6.3. Metabolism of cholesterol
7. Lipoproteins: role in lipid transport and storage (1)
8. Prostaglandins: structure and function (1)
9. Disorders of lipid metabolism (1)
10. Hormones (2)
 - 10.1 Characteristics
 - 10.2 Mechanism of action of peptide and steroid hormones

UNIT-III

11. Hormone receptors and diseases (1)
12. Amino acids and peptides (2)
 - 12.1 Essential and non-essential amino acids
 - 12.2 Porphyrins and bile pigments
- 13 Metabolism of essential amino acids and related disorders (2)
- 14 Small peptides and their biomedical importance (1)
- 15 Structure- conformation-function relationship of proteins: Insulin, Hemoglobin and Collagen (2)

UNIT-IV

- 16 Protein folding and Protein degradation (2)
17. Enzymes: (4)

- 17.1. General properties; Ribozymes
- 17.2. Enzyme kinetics: derivation of Michaelis-Menten equation and calculations based on it & L-B plot
- 17.3. Enzyme inhibition
- 17.4. Mechanism of action (lysozyme & chymotrypsin)
- 17.5. Regulation of enzyme activity
- 18. Nucleic Acids: structure and conformations (2)
- 19. Nucleotide Metabolism: Synthesis and degradation of pyrimidine and purine nucleotides (2)
- 20. Disorders of nucleotide metabolism (1)

Recommended Books

1. Lehninger Principles of Biochemistry, 5th Ed., Nelson & Cox, Freeman, 2008
2. Harper's Illustrated Biochemistry, 27th Ed, Murray et.al. McGraw Hall 2006
3. Biochemistry, 3rd Ed., Zubay et.al, WCB 1993
4. Biochemistry, 5th Ed., Stryer et al, Freeman, 2002
5. Biochemistry, 3rd Ed., Voet&Voet, Wiley, 2004
6. Biochemistry and Molecular Biology, 2nd Ed., Elliot & Elliot, Oxford, 2004
7. Clinical Biochemistry, 6th Ed, Smith et al, Blackwell, 2004
8. Textbook of Medical Biochemistry, 6th Ed, Chatterjee&Shinde, Jaypee, 2005.
9. Text book of Clinical Biochemistry, Davlin
10. Biochemistry, Rawn, J. D.
11. Biochemistry, Mathews

CBCSZ 202: BIOCHEMICAL & MOLECULAR TECHNIQUES, BIostatISTICS AND BIOINFORMATICS

(Credits 3)

Part A: Biochemical&Molecular Techniques

(No. of classes of 60 min each.)

UNIT I

- 1. Centrifugation** (2)
 - 1.1 Basic principle
 - 1.2 Types of rotors
 - 1.3 Clinical, high speed and ultracentrifuge
- 2. Spectrophotometry** (2)
 - 2.1 Types of spectrophotometer
 - 2.2 Beer-Lambert's law, molar extinction coefficient
 - 2.3 Principles of UV- Vis spectrophotometry
- 3. Electrophoresis** (3)
 - 3.1 Principle
 - 3.2 Agarose and polyacrylamide gel
- 4. Chromatography** (3)
 - 4.1 Principle and types
 - 4.2 Column chromatography
 - 4.2.1 Gel filtration
 - 4.2.2 Ion exchange & Affinity chromatography

UNIT II

- 5. Methods in molecular biology and Recombinant DNA techniques**
 - 5.1 Western blotting & In situ hybridization (2)
 - 5.2 DNA foot printing & Electrophoretic mobility Shift Assay (EMSA) (2)
 - 5.5 DNA sequencing (1)
 - 6.1 Restriction enzymes and DNA modifying enzymes (1)
 - 6.2 Cloning vectors (1)
 - 6.3 Preparation and screening of cDNA and genomic DNA libraries (2)
 - 6.4 Southern and Northern hybridizations (2)
 - 6.5 Polymerase chain reaction: principle and applications; Types of PCR (1)
- 7. Types of microscope and their biological applications**
 - 7.1 Bright-field microscope (1)
 - 7.2 Phase contrast microscope (1)
 - 7.3 Fluorescence microscope (1)
 - 7.4 Confocal microscope (1)
 - 7.5 Transmission and scanning electron microscope (2)

UNIT III

Part B: Biostatics

- 8. The mean, mode, median, Standard deviation and Standard error of classified Data (3)
- 9. Hypothesis testing: Chi Square test, f -Test (2)
- 10. Student's t test (1)
- 11. Analysis of variance (one way and two way ANOVA) (2)
- 12. Correlation & Regression (2)

UNIT IV

Section C: Bioinformatics

14. Bioinformatics: Definition, history and scope (1)
15. Analysis of DNA and protein sequences; molecular and genomic databases (e.g., GENE BANK, SWISS-PROT and other databases) (2)
16. Introductory ideas on use of databases for sequence retrieval, similarity search and sequence alignment. (2)
17. Bioinformatics in drug discovery (1)

Books recommended

Biochemical & Molecular Techniques

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
2. Freifelder: Physical Biochemistry (2nded 1982, Freeman)
3. Holme and Peck: Analytical Biochemistry (3rded 1998, Tata McGraw Hill)
4. Plummer: An Introduction to Practical Biochemistry (3rd ed 1990, Tata-McGrawHill)
5. Switzer and Garrity: Experimental Biochemistry (92nded 1999, Freeman)
6. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6th ed 2006, Cambridge University Press)

Bioinformatics & Biostatistics

1. Barnes & Gray: Bioinformatics for geneticists (2003, Wiley)
2. Lesk: Bioinformatics (2nded 2006, Oxford)
3. Westhead et al: Bioinformatics Instant Notes (Indian ed 2003, Viva Books)
4. Mount, Bioinformatics (2nded 2006, CBS)
5. Hunt and Livesey: Functional Genomics (2006, Oxford)
6. Campbel: Discovering Genomics, Proteomics and Bioinformatics (2006, LPE)
7. Fundamental of statistics- D.N. Elhance, VeenaElhance and B.H. Agrawal
8. Mahajan's methods in Biostatistics – ArunBhadraKhanal

CBCSZ -203: IMMUNOLOGY

(No. of classes of 60 mins each)

UNIT-I

1. General introduction to immune system (2)
 - 1.1 Innate and adaptive immunity
 - 1.2 cells and organs of the immune system
 - 1.3 Immune responses
2. Antigens, antibodies and T cell receptors (4)
 - 2.1 Antigens: Immunogenicity vs antigenicity
 - 2.2 Structure and function of antibody: Ig G, Ig M, Ig A, Ig E & Ig D
 - 2.3 Monoclonal Antibodies
 - 2.4 B and T cell receptors and coreceptors
 - 2.5 Antigen-antibody interactions
3. Immunoglobulin (5)
 - 3.1 Organization of Ig gene loci
 - 3.2 Molecular mechanisms of generation of antibody diversity
 - 3.3 Expression of Ig genes
 - 3.4 Regulation of Ig gene transcription
 - 3.5 Antibody Engineering

UNIT-II

4. T cell receptor (2)
 - 4.1 Organization of TCR gene loci
 - 4.2 Generation of TCR diversity
5. The HLA Complex (4)
 - 5.1 General organization & inheritance
 - 5.2 MHC molecules & genes
 - 5.3 Expression of HLA genes
 - 5.4 Regulation of HLA Expression
6. Role of HLA in disease susceptibility (1)
 - 6.1 HLA polymorphism
 - 6.2 Mechanism of disease association and HLA associated diseases

UNIT-III

7. Generation and regulation of immune responses-I (6)
 - 7.1 Antigen processing and presentation and MHC restriction
 - 7.2 Cytokines and Leukocyte, activation and migration
 - 7.3 T cell maturation, activation and differentiation
 - 7.4 B cell maturation, activation and differentiation
8. Generation and regulation of immune responses-II (4)
 - 8.1 Cell mediated cytotoxic responses
 - 8.2 Clonal selection and immunological memory
 - 8.3 Complement system
 - 8.4 Regulation of immune responses and Immunological tolerance
9. Introduction to immunosenescence (1)

Unit IV

10. Human Immune system disorders (4)
 - 10.1 Primary and Secondary Immunodeficiencies
 - 10.2 Auto immunity & auto immune disorders (e.g., RA/SLE/MS)

- 10.3 Hypersensitive reactions
- 10.4 Cytokine related diseases
- 11. Immune system in human health (4)
 - 11.1 Immune response to infectious diseases and malignancy (Immunity to tumors)
 - 11.2 Concept of immunotherapy
 - 11.3 Vaccines
 - 11.4 Transplantation immunology: (Allograft, Xenograft, Syngraft, Graft versus host and host versus graft rejections).
- 12. Basics of Host-Pathogen interaction, evolution of pathogenicity and regulation of virulence (2)
- 13. Mechanism of drug resistance in pathogens: Viruses & Bacteria (1)

Recommended Books

1. Cellular and Molecular Immunology, 6th Ed., Abbas et al, Elsevier, 2007
2. Immunology, 6th Ed Roitt, Mosby, 2002
3. Immunology, 5th Ed., Kuby, Freeman, 2002
4. Microbiology, 6th Ed., Prescott et al, McGraw Hill, 2005
5. Microbiology: A Human Perspective, 4th Ed., Nester et al, McGraw Hill, 2004
6. Medical Immunology, 6th Ed., Virrela, Informa Health Care, 2007
7. Immunology, Janeway & Travers, Garland Publishing Inc, 1994
8. Essential Immunology, Roitt Blackwell 1994
9. Immunology, Roitt et al Mosloy 1993
10. Immunology -A Short Course, Benjamin Wiley-Liss 2000
11. Text Book of Immunology, Barrett Mosloy 1988
12. Biology of Microorganisms, Madigen et al Prentice Hall 1997
13. Introductory Microbiology, Heritage et al Cambridge Univ. 1996
14. Microbiology, Pelczar et al Tata 1993
15. Molecular Diagnosis of Infectious Diseases, Reischel Humana 1998
16. Fundamentals of Immunology, William Paul, Freeman

CBCSZ 204: HISTOLOGY AND MOLECULAR HISTOCHEMISTRY

(Credits 3)

(No. of classes of 60 min each.)

UNIT I

- 1. Fixation and tissue processing** (3)
 - 1.1 Types of fixatives
 - 1.2 Chemistry of fixation
 - 1.3 Choice of fixatives
 - 1.4 Dehydration
 - 1.5 Clearing and embedding
- 2. Microtomy** (4)
 - Types of microtome
 - 2.1 Sectioning of paraffin blocks
 - 2.2 Cryosectioning
 - 2.3 Vibratome
- 3. Staining of paraffin sections** (3)
 - 3.1 Principle and methods of staining
 - 3.2 Histological stains: haematoxylin and eosin

UNIT II

- 4. Gross Histology of tissue types:**
 - 4.1 Connective tissue (2)
 - 4.2 Cartilage (1)
 - 4.3 Bone (1)
 - 4.4 Cerebrum, cerebellum and spinal cord (3)
 - 4.5 Heart (1)
 - 4.6 Kidney (1)
 - 4.7 Liver (1)
 - 4.8 Gall bladder (1)
 - 4.9 Lungs (1)
 - 4.10 Testis and ovary (2)
 - 4.11 Thyroid gland (1)

UNIT III

- 5. Principles and methods of histochemical localization and identification of:**
 - 5.1 Carbohydrate moieties
 - 5.1.1 Glycogen and glycoproteins with oxidizable vicinal diols by periodic acid Schiff Method (2)
 - 5.1.2 Glycoproteins with carboxyl groups and/or *O*-sulphate esters by alcian blue Methods (2)
 - 5.1.3 Role of lectin in carbohydrate histochemistry (1)
 - 5.2 Protein end groups (4)
 - 5.2.1 General protein localization by bromophenol blue method
 - 5.2.2 $-NH_2$ groups by Ninhydrin-Schiff method
 - 5.2.3 $-S-S-$ groups by performic acid-Schiff and performic acid-alcian blue methods

UNIT IV

- 5.3 Lipids moieties (3)
 - 5.3.1 General lipids by Sudan black B method
 - 5.3.2 Neutral lipids by Sudan III and Sudan IV methods
 - 5.3.3 Differentiation of neutral lipids from acidic lipids by Nile blue sulphate method
- 5.4 Nucleic acids (2)
 - 5.4.1 Methyl green pyronin-Y for DNA and RNA
 - 5.4.2 Feulgen reaction for DNA
- 5.5 Enzyme activity (3)
 - 5.5.1 Principles of enzyme histochemistry
 - 5.5.2 Acid and alkaline phosphatases by metal precipitation and azo dye methods
- 6. Basic principles of immunohistochemistry and fluorescence staining (3)**
- 7. In situ hybridization (1)**

Books recommended

Histology & Histochemistry

1. Bancroft & Stevens: Theory and Practice of Histological techniques (2013, Churchill-Livingstone)
2. Casselman: Histochemical techniques (1959, John Wiley)
3. Pearse: Histochemistry: Theoretical and Applied (Vol. I, II & III) (4th ed 1980-1993, Churchill-Livingstone)
4. Kiernan: Histological and Histochemical Methods (4th Ed. Scion 2008)

LABORATORY EXERCISES
CBCSZ 205: BIOCHEMISTRY AND BIOCHEMICAL &
MOLECULAR TECHNIQUES, BIOSTATISTICS &
BIOINFORMATICS
(Credits 3)

Biochemistry

13. Preparation of extract for enzyme assay (alkaline phosphatase)
- 13.1 Study of alkaline phosphatase activity
- 13.2 Standard curve preparation
- 13.3 Effect of enzyme concentration and determination of total and specific activity
- 13.4 Effect of temperature on enzyme activity
- 13.5 Effect of time on enzyme activity
- 13.6 Effect of substrate concentration on enzyme activity
- 13.7 Determination of K_m and V_{max} by Michaelis-Menten and Lineweaver-Burk
14. Preparation of casein from milk
15. Detection of carbohydrates/proteins/ lipids in the given sample.
16. Testing of blood glucose using glucometer.
17. To estimate the level of glucose in serum sample by enzymatic GOD-POD (Glucose oxidase-peroxidase) method.
18. To estimate cholesterol and HDL cholesterol in serum sample.

Biochemical and Molecular Techniques

1. Verification of Beer's law and preparation of absorption spectrum of riboflavin
2. Demonstration of separation of protein by SDS-polyacrylamide gel electrophoresis
3. Isolation of plasmid, restriction digestion and determination of size by agarose gel electrophoresis
4. pH meter and determination of pH of a buffer
5. Demonstration of DNA amplification by polymerase chain reaction
6. Isolation of genomic DNA by spooling/ precipitation method and its quantitation
7. Agarose gel electrophoresis
8. Isolation and identification of lipids by TLC
9. Determination of amino acids by paper chromatography
10. Estimations of fractionated molecules through spectrophotometric methods
- 10.1 Protein by Biuret/Folins method
- 10.2 DNA by diphenylamine method
- 10.3 RNA by orcinol method
11. Feulgen study of DNA.
12. Demonstration of Phase contrast microscope/confocal microscope/ fluorescence microscope

Bioinformatics & Biostatistics

1. Use of search engines (Google, Altavista, Dogpile, Meta-crawler)
2. Demonstration of web-pages related to biological information (NCBI, ExPasy)
3. Hands on practice to features of following databases: GenBank, PDB, DIP, PubMed, Toxnet, OMIM, Fly Base, etc.

4. Hands on practice to features of following software packages/tools: BLAST, Clustal-W, PHYLIP
5. Estimation of mean, median, mode, standard error and standard deviation
6. Demonstration of correlation
7. Working on examples of X^2 (Chi square) test for hypothesis testing

Scheme

Q.1 Practical based on molecular techniques	(6)
Q.2 Chromatography TLC/Paper chromatography	(6)
Q.3 Practical based on bioinformatics/Biostatistics	(6)
Q.4 Practical based on enzymatic action/alkaline phosphatases activity	(6)
Q.5 To estimate the protein/carbohydrate/lipids in given sample/ level of glucose in serum sample by enzymatic GOD-POD	(6)
Q.6 Spotting (8x2)	(16)
Q.7 Viva voce	(8)
Q.8 Practical record	(6)

Total marks 60

**CBCSZ 206: HISTOLOGY, MOLECULAR HISTOCHEMISTRY
AND IMMUNOLOGY
(Credits 3)**

Histology and Histochemistry

1. Preparation of histological sections
 - 1.1 Fixation of tissue
 - 1.2 Dehydration, clearing and embedding of tissue
 - 1.3 Sectioning and spreading of sections
2. Histological staining of paraffin sections using haematoxylin and eosin method
3. Histochemical staining to demonstrate lipids using sudanblack B method and carbohydrate using PAS technique/ methyl green pyronin Y staining for nucleic acid/ bromo phenol blue staining for protein
4. Preparation of different histochemical stains.

Immunology

1. Demonstration of antigen-antibody reaction by immunodiffusion
2. Demonstration of direct ELISA
3. Blood film preparation and identification of cells.
4. Study of lymphoid organs and their microscopic structure.
5. Study of antigen-antibody interaction.
6. Immunodiagnosis (Demonstration using commercial kits)
7. Precipitation and agglutination reactions
8. Study of cell types of immune system
9. Immuno-localization of antigens

Scheme

Q.1 Experiment on immunology ELISA / immunodiffusion/ Immunodiagnosis (kit based)	(6)
Q.2 Precipitation and agglutination reactions /Study of cells of immune system/Immuno-localization of antigens	(6)
Q.3 Preparation of histological section of given mammalian tissue (8) (Fixation to slide preparation)	
Q.4 Histochemical staining of the given material to demonstrate biomolecule (protein/lipid/carbohydrate/Nucleic acid).	(8)
Q.5 Spotting	(16)
Q.6 Viva voce	(10)
Q.7 Practical record	(6)

Total marks	60

SEMESTER III
CBCSZ301: DEVELOPMENTAL BIOLOGY
(Credits 3)

(No. of classes of 60 min each.)

UNIT I

1. Introduction to Development: Generation of new cells and organs: Specification, determination and differentiation. (2)
2. Cell-Cell communication in development, cell adhesion, cell migration, cell signaling, paracrine factors. (3)
3. Fertilization: The mechanism: External fertilization in Sea Urchins, polyspermy and its restriction; internal fertilization in Mammals. (3)
4. Vulva formation in *Caenorhabditiselegans*. (1)

UNIT II

5. Early development and axis specification in insect (*Drosophila*) (2)
6. Early development in Fish and Amphibians: Zebra fish and Amphibian cleavage and Gastrulation, mechanism of Amphibian axis specification. (3)
7. Early development in Birds: Gastrulation in Avian embryo, Axis specification. (2)
8. Mammalian Gastrulation and axis formation. (2)

UNIT III

9. Formation of neural tube, differentiation of Neurons and formation of the Brain. (3)
10. Neural Crest Cells, Pattern generation in nervous system. (2)
11. Development of Eye and Cutaneous Appendages. (2)
12. Development of Heart and formation of Blood vessels. (3)
13. Development of Limbs in vertebrates. (2)

UNIT IV

14. Theories of aging and senescence. (2)
15. Metamorphosis. (2)
16. Regeneration in Flat worms, Hydra, Salamander and liver. (3)
17. Cancer: environmental, genetic and chromosomal basis; transformation & malignancy. (2)
18. Environment and Development. (2)

Recommended Books:

1. Developmental Biology, 8th Ed., Gilbert, Sinauer, 2006
2. Principles of Developmental Genetics, Moody, Elsevier, 2007
3. Principles of Development, 2nd Ed., Wolpert, Oxford 2002
4. The Cellular & Molecular Biology of Pattern Formation, Stocum & Karr, 1990
5. Langman's Medical Embryology, 10th Ed., Sadler, LMW, 2006
6. Human Embryology and Teratology O'Rahilly and Muller Wiley 1992
7. An introduction to Embryology, B.L. Balinsky,

CBCSZ 302: MAMMALIAN PHYSIOLOGY AND ENDOCRINOLOGY

(No. of classes of 60 min each.)

UNIT I

- 1. Muscle (5)
 - 1.1 Muscle proteins and their function
 - 1.2 Types of contraction and muscle relaxation
 - 1.3 Mechanism and energetics of muscle contraction
- 2. Digestion (5)
 - 2.1 Digestion and absorption of macronutrients
 - 2.2 Digestive glands
 - 2.3 Regulation of digestion (neural, hormonal and enzymatic)
- 3. Excretion (5)
 - 3.1 Urine formation and regulation
 - 3.2 Acid-base balance and homeostasis
 - 3.3 Renal function tests

UNIT II

- 4. Respiration (8)
 - 4.1 Pulmonary ventilation
 - 4.1.1 Respiratory centers: organization and function
 - 4.1.2 Surfactant
 - 4.2. Exchange and transport of respiratory gases
 - 4.3 Respiratory adjustments
 - 4.3.1 Hypoxia and oxygen therapy
 - 4.3.2 Dyspnea
- 5. Circulation (6)
 - 5.1 Blood: Haematopoiesis
 - 5.2 Heart: Structure and function
 - 5.2.1 Origin and conduction of cardiac impulse
 - 5.2.2 Cardiac cycle and ECG

UNIT III

- 6. Nervous system: Mammalian brain, Central nervous system, Physiology of nerve conduction and role of neurotransmitters (4)
- 6.1 Physiology of vision in mammals (2)
- 7. Reproduction: (6)
 - 7.1 Male reproductive system and physiology
 - 7.2 Female reproductive system and physiology
 - 7.3 Hormones and mammalian reproduction

UNIT IV

- 8. Endocrinology: history and scope; environment and hormones (1)
 - 8.1 Brief idea of general organization of mammalian endocrine system (e., pituitary, hypothalamus, thyroid, parathyroid, pineal body, pancreas and adrenal glands) (4)
 - 8.2 Hormones of various endocrine organs and their general functions; Mechanism of hormone action; Pheromones. (2)
 - 8.3 General idea of Neuroendocrine systems of invertebrates: insects, crustaceans and Mollusca (3)

Books Recommended

Mammalian Physiology & Endocrinology

1. Ganong: Review of Medical Physiology (22nd Ed 2005, Lang Medical Publications)
2. Guyton and Hall: Text Book of Medical Physiology (11th Ed 2006, W.B. Saunders)
3. Keel et al: Samson Wright's Applied Physiology (13th Ed 1989, Oxford Press)
4. West: Best and Taylor's Physiological Basis of Medical Practice (11th Ed 1981, Williams and Wilkins)
5. Human Physiology; Dr. C.C. Chatterjee
6. General animal physiology; R.C. Chaurasiya
7. A. Text book of Animal Physiology; K.A. Goel
8. Biological Phosphorylation; Herman N. Kalekar
9. General & Comparative Physiology 2nd Edition; William S. Hoar
10. A Text Book of Animal Physiology; R. Nagabhushnam
11. Principle of Animal Physiology; D. Moyes
12. General & comparative endocrinology; E.J.W. Barrington
13. Animal endocrinology; Manju Yadav
14. The Comparative endocrinology of invertebrates; Kenneth C. Highnam
15. Comparative endocrinology; U.S. Von Euler
16. The endocrine system and the environment; Brian K. Follett

ELECTIVE PAPERS
A. AQUATIC BIOLOGY AND AQUACULTURE
CBCSZ 303 (A) AQUATIC ECOLOGY & RESOURCES

(No. of classes of 60 min each.)

UNIT I

1. Aquatic ecology: Science and its development (1)
2. Origin and classification of wetlands including lakes (2)
3. Morphology of lakes, reservoirs and ponds (2)
4. Marine ecosystem; concept principal components and biological characteristics of marine environment (2)
5. Estuaries and other brackish water environments in India and their faunal importance (2)

UNIT II

6. Physical and chemical characteristics of lakes, ponds and rivers (2)
7. Freshwater biota: Plankton, benthos and macrophytes (2)
8. Food chain, food web, trophic levels and energy flow (2)
9. Primary productivity in Inland water and methods of its determination (2)
10. Degradation of wetland in India and control measures (2)

UNIT III

11. Aquatic resources: Invertebrates and vertebrates (2)
12. Importance and management of aquatic resources in India (2)
13. Migration pattern of aquatic animals including aquatic birds (2)
14. Threatened wetlands and endangered aquatic species (2)
15. Aquatic wild life: Habitat and its importance, composition and conservation strategies (2)

UNIT IV

16. Aquatic pollution, its causes and control measures (2)
17. Major sources of pollution in rivers and remedies (2)
18. Biological indicators of water pollution (2)
19. Eutrophication, its impact on water bodies and control measures (2)
20. Aquatic toxicology: Aquatic toxicity, long-term toxicity and chronic toxicity(3)

CBCSZ 304 (A): FISH BIOLOGY & PHYSIOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Structure and functions of skin and scales, significance of scales in taxonomy (3)
2. Chromatophores: Classification, ultrastructure and functional significance (2)
3. Origin of paired fins and modification of caudal fin (2)
4. Respiratory organs including accessory respiratory organs and respiration in fish (3)
5. Swim bladder and its functional significance (1)

UNIT II

6. Food, feeding habits and nutrition in fish (2)
7. Digestive system and physiology of digestion in fish (3)
8. Osmoregulatory organs and osmoregulatory mechanisms in fish (3)
9. Brain of fishes and its functional organization in relation to ecological conditions (3)
10. Lateral line system: Structure, modifications and functional significance (2)

UNIT III

11. Electric organs and their significance (2)
12. Bioluminescence in fish and its significance (2)
13. Chemical communication in fish (2)
14. Neuro-endocrine integration and hypothalamo-hypophysial system in fish (3)
15. Anatomy and physiology of pituitary gland (2)

UNIT IV

16. Anatomy and physiology of thyroid gland (2)
17. Pineal organ, inter-renal gland and caudal neurosecretory system (3)
18. Seasonal cycles of gonads in Indian fish (3)
19. Hormonal and environmental control of reproduction in fish (3)
20. Development of teleost fish (3)

Suggested Readings:

Brown, M.E. **The Physiology of Fishes, Vol.I& II.** Academic Press, New York.
Lagler, K.F. Bardach, J.E., Miller, R.R. and Passino, D.R.M. **Ichthyology.** John Wiley & Sons, New York
Hoar and Randall. **Fish Physiology Vol.1-16.** Academic Press, New York.
Nikolsky, G.V. **The Ecology of Fishes.** Academic Press, New York.

**LIST OF PRACTICAL EXERCISES FOR LABORATORY
COURSE
CBCSZ 306 (A) AQUATIC BIOLOGY & AQUACULTURE**

- Analysis of water samples for physico-chemical and biological characteristics including water depth, transparency turbidity, temperature, nutrients (Phosphates, nitrate, silicates)
- Macrobenthic fauna and its estimation
- Preparation of permanent mounts of planktonic organisms
- Physico-chemical analysis of soil of fish pond
- Field studies or river, stream and reservoir ecosystems, wetland sanctuaries and parks
- Microtomy of fish and shell fish material: block making, sectioning and staining
- Anatomy of fish, sexual dimorphism in carp and other fish
- Identification of maturity stages of gonads and estimation of GSI of fish.
- Dissection of cranial nerves of catfishes and carps
- Gills and accessory respiratory organs of fishes
- Alimentary canals of carps, catfishes and murrels
- Qualitative analysis of food of fish.
- Estimation of gastrosomatic index and hepatosomatic index of fish
- Biochemical estimation of fish constituents
- Acute toxicity determination for freshwater fish
- Experiments on fish behaviour
- Age determination with the help of scales and other materials

Scheme

Q.1 Major Dissection	(8)
Q.2 Minor Dissection	(6)
Q.3 Exercise on physiochemical properties of water	(8)
Q.4 Histology of fish material	(10)
Q.5 Identification of maturity stages and estimation of variable indexes	(8)
Q.6 Age determination of fish with the help of scales	(6)
Q.7 Viva voce	(8)
Q.8 Practical record	(6)

Total marks 60

B. CELLULAR NEUROBIOLOGY AND HUMAN GENETICS
CBCSZ 303 (B): CELLULAR AND MOLECULAR
NEUROBIOLOGY

(No. of classes of 60 min each.)

UNIT I

1. An overview of the nervous system (3)
2. Neurons: Introduction to neurons, The Neuron Doctrine, The Nissl and Golgi stains, Components of neurons (3)
3. Classification and types of neurons, Cytology of neurons (2)
4. Dendrites structure and function, Axons structure and functional aspects, myelination and synapses (3)
5. Glial cells: Structure and function of glial cells, Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells (4)

UNIT II

6. Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, Importance of astrocytes in glutamate metabolism and blood brain barrier (3)
7. Functions of other glial cells: oligodendrocyte and microglial cells, Microglial phenotypes, (3)
8. Overview of glial and neuronal relationship in the CNS (3)
9. Glial –neuronal interplay in the CNS (2)

UNIT III

10. Gross anatomy of the adult brain; organization of the nervous system (4)
11. Subdivisions of the nervous system; Concept of CNS, ANS & PNS (3)
12. The scalp, skull and meninges (3)
13. Cerebrospinal fluid (2)
14. Constitutions of CNS: Overview; Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of axons (4)

UNIT IV

15. Peripheral nervous system: General organization; nerves, roots and ganglia; sensory endings (5)
16. Synaptic transmission and cellular signaling (3)
17. Brief idea on chemistry, synthesis, storage and receptors of neurotransmitters: Acetylcholine, catecholamine, serotonin, etc. (4)
18. Blood brain barrier (3)
19. CSF brain barrier (3)

CBCSZ 304 (B): METHODS IN MOLECULAR GENETIC ANALYSES

(No. of classes of 60 min each.)

UNIT I

1. Immunotechniques: Precipitation, immunofluorescence, ELISA and RIA (2)
2. Methods of protein purification (1)
3. DNA-protein interactions: Electrophoretic mobility shift assay (gel shift assay) and DNA foot printing (2)
4. General idea of DNA micro-array (DNA chips and Affymetrix). (1)
5. Introduction to DNA finger printing, RAPD and RFLP (3)

UNIT II

6. Methods in analysis of gene expression: Transformation, transfection and mammalian expression vectors (3)
7. Methods in gene (promoter, transcription factors, etc.) analysis: Eukaryotic promoter structure and promoter elements, Linker scanning mutation & deletion analysis, Reporter assay (3)
8. General idea of two-hybrid systems, Subtractive hybridization, Chromosome walking & Chromosome jumping (2)
9. RNA analysis: RNAase protection assay, Primer extension & S1 nuclease protection assay for mapping ends/of RNA transcripts (1)
10. DNA methylation and DNAase I Hypersensitivity in relational to gene activity and chromatin organization (2)

UNIT III

11. Identifying genes: Positional cloning and confirming candidate gene (2)
12. Human Genome Project and Human Genome Diversity Project (2)
13. Strategies for physical mapping of genome: STS/EST markers, Cell Hybrids, YAC/ BAC/PAC clone contigs (2)
14. Introduction to SNPs & SNP typing (1)

UNIT IV

15. Introduction to Comparative genomics (*Caenorhabditis*, *Drosophila*, mouse and human) (2)
16. Approaches to transcriptome analysis (sequence based and hybridization based) (2)
17. Approaches to proteomics (gel electrophoresis, Western, mass spectrometry, peptide Sequencing, gene-protein and protein-protein interactions) (2)
18. Elementary idea of Genome-wide Association Studies (GWAS) and Next Generation Sequencing (NGS) (20)

Suggested Readings:

Tom Strachan & Andrew P Read, Human Molecular Genetics 3/4
Watson, Hopkins, Roberts, Steitz, Weiner. Molecular Biology of the Gene. The Benjamin/Cummings Publishing Company Inc.
Bruce Alberts, Bray, Lewis, Raff, Roberts, Watson. Molecular Biology of the Cell. Garland Publishing Inc.
Watson, Gilman, Witkowski, Zoller. Recombinant DNA. Scientific American Books
Gerald Karp. Cell Biology.
Lewin B. Genes VII.
Daniel L. Hartl, Elizabeth W. Jones. Genetics-Principles and Analysis. Jones and Bartlett Publishers.
Lodish, Berk, Zipursky, Matsudaira, Baltimore, Darnell. Molecular Cell Biology. W. H. Freeman and Company.
J. Travers. Immunology. Current Biology Limited.
Kuby. Immunology. W. H. Freeman and Company.
Roitt. Male, Snustad, Immunology.
Gardner, Simmons, Snustad. Principles of Genetics. John Wiley and Sons Inc.
Gibson, Muse. A Primer to Genome Science. Sinauer Associates Inc., Publishers
S. M. Brown. Bioinformatics. Eaton Publishing.
Prescott, Harley, Klein. Microbiology. Wm C. Brown Publishers
T. A. Brown. Gene Cloning.
T. A. Brown, Genomes.
D. Freifelder. Physical Biochemistry.
Sambrook, Fritsch, Maniatis. Molecular Cloning, Vol I-III.
Ausbel, Brent, Kingston, Moore, Seidman, Smith, Struhl. Current Protocols in Molecular Biology, Vol I-II. Green Publishing Associates.

Books in Neurobiology

Siegel, Basic Neurochemistry (7th Edition) Academic Press, 2006
Alberts, Molecular Biology of the Cell (5th Edition) Garland Science, 2008
Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007

**LIST OF PRACTICAL EXERCISES FOR LABORATORY
COURSE
CBCSZ 306 (B) METHODS IN CELL AND MOLECULAR
BIOLOGY**

- Dissection of nervous system of rat as experimental model.
- Perfusion techniques
- Procedure for removal of various parts of nervous system of rat i.e., cerebral hemisphere, cerebellum, mid brain, medulla oblongata, spinal cord and tissue processing for microtomy/cryotomy
- Histological localization of nervous and glia in nervous system.
- Histochemical demonstration of lipids, proteins (including enzymes), carbohydrate and nucleic acids (DNA/RNA)
- Immunocytochemistry: Intracellular localization of specific target molecules by antibody staining
- Fluorescence microscopy and immunofluorescence: Application of fluorochromes and fluorochrome tagged antibodies
- Gel electrophoresis of proteins: Tissue isolation and Separation of proteins by polyacrylamide gel electrophoresis (PAGE), starch gel.
- Gel electrophoresis of nucleic acids (DNA/RNA): Isolation and detection of DNA/RNA on agarose gel & PAGE, Silver staining.
- Preparation of mitotic chromosomes from rat/mice bone marrow cells and construct karyotype of G-or C-banded chromosomes
- Short terms rat/human blood lymphocyte culture and preparation of mitotic chromosomes for karyotyping
- Study of permanent slides and electron micrographs

Scheme:

Q1. Histology preparation and staining of nervous tissue/histochemical demonstration of biomolecules/Immunocyto/Histological preparation	(10)
Q2. Electrophoresis of nucleic acid/Protein	(8)
Q3. Mitotic (Bone marrow)/Human karyotyping/G-banding	(8)
Q4. Spot (8x2)	(16)
Q5. Viva voce	(10)
Q6. Practical record	(8)

Total marks 60

C. ENDOCRINOLOGY
CBCSZ 303 (C): COMPARATIVE ENDOCRINOLOGY

(No. of classes of 60 min each.)

UNIT I

1. History and scope of endocrinology (2)
2. Endocrine methodologies (2)
3. Mechanism of hormone action (2)
4. Hormones and environment (2)
5. General and comparative structure of anterior pituitary gland (3)

UNIT II

6. General and comparative structure of neurohypophysis (3)
7. General and comparative structure of thyroid (3)
8. General and comparative structure of parathyroid (2)
9. General and comparative structure of pancreas (3)
10. Structure of mammalian pineal body (2)

UNIT III

11. General and comparative structure of adrenal medulla and chromaffin tissue (3)
12. General and comparative structure of adrenal cortex and inter-renal tissue (3)
13. Neurosecretion and neuroendocrine mechanisms in non-arthropod invertebrates (3)
14. Neuroendocrine system in Crustacea (2)
15. Neuroendocrine system in Insecta (2)

UNIT IV

16. Neuroendocrine system in Mollusca (2)
17. Caudal neurosecretory system in fish (2)
18. General structure of thymus (1)
19. Endocrine integration : migration of birds and fishes, bird plumage (3)
20. Hormone like substances :Ectohormones, phytohormones, root growth hormones, (3)

CBCSZ 304 (C): ENDOCRINE PHYSIOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Role of hypothalamus and neuroendocrine integration in mammals (3)
2. Hormones of anterior pituitary and their functional significance (4)
3. Hormones of neurohypophysis and their functional significance in mammals (2)
4. Hormones of pars-intermedia and control of pigmentary function in vertebrates (2)
5. Functional significance of pineal hormones (2)

UNIT II

6. Biosynthesis and functions of thyroid hormones (3)
7. Regulation of thyroxine secretion (2)
8. Thyroxine and its influence on development and metamorphosis (3)
9. Parathyroid hormone and its physiological significance (2)
10. Calcitonin, thyrocalcitonin and their functional significance (4)

UNIT III

11. Catecholamines (epinephrine and nor-epinephrine) their biosynthesis and physiological influence on metabolism (4)
12. Physiological significance of mineralocorticoids and glucocorticoids (3)
13. Gastrointestinal hormones and their physiological significance (3)
14. Insulin and insulin like peptides and their role in early mammalian development (2)
15. Renin and angiotensins and their functional significance (2)

UNIT IV

16. Physiological significance of insulin in carbohydrate metabolism (2)
17. Physiological significance of glucagon in carbohydrate metabolism (2)
18. Biochemistry and functional significance of sex steroids (2)
19. Role of hormones in insect physiology (2)
20. Role of hormones in crustacean physiology (2)

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

CBCSZ 306 (C) COMPARATIVE ENDOCRINOLOGY & ENDOCRINE PHYSIOLOGY

- Dissection of endocrine glands in vertebrate and invertebrates (suitable insect such as cockroach, grasshopper, dipteran larvae)
- Determination of proteins, /cholesterol/ sugar level using spectrophotometer
- Separation of plasma proteins using electrophoresis
- Microtomy of endocrine material (tissue fixation, processing, paraffin block preparation, sectioning, staining and mounting)
- Study of slides of endocrine material from different animals
- Identification of chemical structures of peptides and steroid hormones
- Study of electron micrographs
- Estimation of hormones in blood
- Study of Comparative structure of endocrine glands of selected vertebrates and invertebrates

Scheme:

Q.1 Dissection of endocrine glands in vertebrate/ invertebrate/ Microtomy of endocrine material	(8)
Q.2 Estimation of hormones in blood/Quantitative estimation of proteins/ cholesterol/ blood sugar level	(8)
Q.3 Separation of plasma proteins using electrophoresis/Study of Comparative structure of endocrine glands	(8)
Q.4 Spotting -8 (slides – 4, molecular structure of hormones – 1, electron micrograph – 3) (2.5x8)	(20)
Q.5 <i>Viva voce</i>	(8)
Q.6 Practical record	(8)

	Total marks 60

D. ENTOMOLOGY
CBCSZ 303(D): GENERAL ENTOMOLOGY & INSECT
MORPHOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Introduction, history and scope of Entomology
2. Fossil insects and origin and evolution of insects
3. Insect diversity and their outline classification
4. Coloration and mimicry in insects
5. Light production in insects

UNIT II

6. Insect collection: Significance and insect nets and traps
7. General organization of a typical insect body
8. Head segmentation and its theories
9. Structure of insect head, structure and functions of antennae
10. Different types of mouth parts and relationship with feeding habits of insects

UNIT III

11. Structure of insect legs, their modifications and functions
12. General structure of insect abdomen and its appendages
13. Structure of typical wing bearing thoracic segment; Structure of insect wings, their modifications and wing coupling apparatus
14. Hypothetical wing venation; Wing venation in grasshopper, housefly and honeybee
15. Structure of flight muscles and flight mechanisms in insects

UNIT IV

16. Male and female genitalia in grasshopper
17. Sound production and reception in insects
18. Phase theory of locusts
19. Polymorphism in aphids
20. Methods of insect communication

CBCSZ 304 (D): INSECT ANATOMY AND PHYSIOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Structure and functions of insect integument
2. Mechanism of moulting and sclerotization of cuticle
3. Structure and types of spiracles; Tracheal system in a generalized insect and mechanism of respiration
4. Respiration in aquatic and parasitic insects
5. Photoreceptor organs: Simple and compound eyes, formation of image

UNIT II

6. Structure of Malpighian tubules including cryptonephridia
7. Physiology of excretion and significance of cryptonephridia
8. Structure of brain and ganglia; Variation in central nervous system in different insect orders
9. Structure and functions of mechanoreceptors
10. Structure and functions of chemoreceptors

UNIT III

11. Structure and functions of fat body; Composition and functions of haemolymph
12. Insect circulatory system
13. Digestive system: Structure and modifications of alimentary canal and associated glands
14. Histology of alimentary canal, salivary glands and peritrophic membrane
15. Physiology and regulation of digestion

UNIT IV

16. Neuroendocrine system and its variations in different insects
17. Chemistry and functions of hormones
18. Structure of male and female reproductive systems
19. Types of insect reproduction
20. Insect pheromones

LIST OF PRACTICAL EXERCISES
ZOOL. 306 (D): GENERAL ENTOMOLOGY

1. Dissection / demonstration of insect organ systems (nervous, digestive, reproductive, neuroendocrine) in insects like grasshopper, cricket, cockroach, wasp, honey bee, insect larvae.
2. Preparation of permanent stained mounts of insects, their body parts and dissected organs.
3. Study of permanent slides of insects, their body parts, organs and histological preparations
4. Study of insect specimens showing colouration, mimicry, light production, polymorphism, sound production and reception and other morphological modifications
5. Physiological experiments in insects like extirpation and implantation of endocrine organs, parabiosis, ligation of dipteran / lepidopteran larvae, preparation of isolated abdomen demonstration of digestive enzymes, excretory products etc.
6. Microtomy of insect material
7. Biochemical analyses like chitin test, demonstration of cuticular lipids
8. Estimation of total proteins, SDS PAGE of haemolymph proteins

E. FISH BIOLOGY AND FISHERIES:
CBCSZ 303 (E): FISH STRUCTURE AND FUNCTION

(No. of classes of 60 min each.)

UNIT I

1. Structure and function of skin; Structure and function of scales, determination of growth and age
2. Origin and evolution of paired fins; Different types of fins and their specific modifications
3. Skeleton of teleost fish
4. Locomotion in fish
5. Structure and function of swim bladder

UNIT II

6. Accessory respiratory organs with special reference to Indian fishes
7. Different types of feeding and feeding habits of fish
8. Structure, function and homologies of Weberian ossicles
9. Hill stream adaptation in fish
10. Deep sea fishes

UNIT III

11. Migration in fish
12. Chemical communication in fish
13. Structure and functions of electric organs and electroreceptors
14. Structure and function of luminous organs
15. Structure and function of sound producing organs and sound reception

UNIT IV

16. Poisonous and venomous fish.
17. Structure, working and functions of eye
18. Structure, working and functions of ear
19. Hybridization in fish
20. Sex determination in fish

CBCSZ 304 (E): FISH MORPHOLOGY, ANATOMY AND PHYSIOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Chromatophores: Classification, ultrastructure, and functional significance
2. Color changes: Types, neural and endocrine control mechanisms
3. Respiratory organs: Kinds and physiology of aqueous breathing
4. Digestive system: Anatomy and physiology of alimentary canal
5. Nervous system: Brain its functional organization with ecological bearing

UNIT II

6. Nervous system: Nerves and their supply
7. Lateral line system: structure, modifications and significance
8. Circulatory system in fish, heart, venous and arterial system
9. Excretory system: kidney and physiology of excretion in teleost fish
10. Osmo-regulatory organs and mechanisms in fish

UNIT III

11. Neuroendocrine integration in fish
12. Hypothalamohypophysialneurosecretory system in fish
13. Anatomy and physiology of the pituitary gland
14. Anatomy and physiology of the thyroid gland
15. Pineal organ, interrenal tissue and caudal neurosecretory system

UNIT IV

16. Seasonal cycles of male and female gonads
17. Hormonal control of reproduction
18. Environmental control of reproduction
19. Early development of a teleost
20. Parental care in fish

Suggested Readings:

- Leo.S.Berg Classification of fishes (fossilized & Recent).
Francis day Voll & II Fishes of India.
C.B.LShrivastava, Fish Biology.
K.S.Mishra: An aid to classification of Fishes.
GopaljiShrivastava: Indian of fishes of U.P. & Bihar.
B.Qurashi: Identification of fishes.
W.D.Rusell: Aquatic Productivity.
A.J.K.Mainan: Identification of fishes.
K.F.Lagler: Ichthyology.
N.R.Rao: An Introduction of fishes.
J.F.Norman: An History of fishes.
S.S.Khanna: An Introduction of fishes.
R.L.Rath: Fresh water Aquaculture.
H.R.Singh: Advance in fish Biodiversity.
H.D.Kumar: Sustainability & Management of Aquaculture & Fisheries.
Arugun & Natarajan: Fresh water Aquaculture.
Arugun & Natarajan: Santanu-Costal Aquaculture.
R.Sanatham: A manual of fresh water Aquaculture.

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

CBCSZ 306 (E): FISH BIOLOGY

1. Anatomy of various organ systems and mounting of fish materials
2. Cranial nerves of teleost fishes: Wallago, Mystus, Labeo and other fishes
3. Osteology of fish: Scoliodon, carps, catfishes, murrels etc.
4. Accessory respiratory organs of air breathing fish
5. Study of histological (permanent) slides
6. Study of museum specimens of the concerned group

Scheme

CBCSZ 305: DEVELOPMENTAL BIOLOGY, MAMMALIAN PHYSIOLOGY AND ENDOCRINOLOGY

(Credits 3)

Developmental Biology

1. Study of frog embryonic development through models/slides/museum specimens.
2. Study of developmental stages of Zebra fish.
3. Study of life cycle of model systems (e.g. Mouse/rat, Zebra fish, *C. elegans*, *Drosophila*, etc.)
4. Study of embryonic development in chick through slides
5. Whole mount preparation of chick embryos at various stages of development
6. Observation of aristopedia and bithorax mutants of *Drosophila*
7. Study of metamorphosis in *Drosophila* larvae by ligature experiments
8. Study of electron micrograph of spermatogenesis and oogenesis.

Mammalian Physiology

1. Differential leucocytes/ erythrocytes counting in blood
2. Determination of blood groups (ABO and Rh factor)
3. Determination of haemoglobin percentage in blood of rat/man.
4. Determination on clotting time of rat/human blood.
5. Determination of erythrocytes sedimentation rate of rat/human blood.
7. Estimation of ascorbic acid content in lemon extracts using titration method
8. Demonstration of salivary digestion.
9. Detection of urea/uric acid/ ammonia in the given sample.
10. Detection of abnormal constituents in urine.
11. Demonstration of endocrine glands in rat/mouse.
12. Demonstration of pregnancy through commercial kit (HCG).
13. Demonstration of insulin level in diabetic patients.
14. Preparation and study of histological slides of various endocrine glands.

Scheme

Q.1 Whole mount preparation of chick embryo to study various developmental stages / study of developmental stages of Zebra fish	(8)
Q.2 Differential leucocytes/ erythrocytes counting in blood	(8)
Q.3 Determination of haemoglobin percentage/erythrocytes sedimentation rate human blood/ Pregnancy test through HCG	(6)
Q.4 Estimation of ascorbic acid content in lemon extracts using titration method/ Detection of excretory products in urine/ To estimate the insulin level in diabetic patients	(6)
Q.5 Spotting (08)	(16)
Q.6 Viva voce	(10)
Q.7 Practical record	(6)

Total marks 60

SEMESTER IV
CBCSZ 401: TAXONOMY & EVOLUTION
(Credits 3)

(No. of classes of 60 min each.)

UNIT I

1. Definition and basic concepts of biosystematics and taxonomy; Trends in biosystematics: Chemotaxonomy, cytotaxonomy and molecular taxonomy (3)
2. Dimensions of speciation and taxonomic characters (2)
3. Species concept: Different species concepts (2)
4. Species category, sub-species and other infra-specific categories (2)
5. Theories of biological classification (2)

UNIT II

6. Taxonomic categories & Hierarchy of categories (2)
7. Taxonomic characters: Different kinds, origin of reproductive isolation, biological mechanism of genetic incompatibility (3)
8. Taxonomic procedures: Taxonomic collections, preservation, curation, process of identification (2)
9. Taxonomic keys: Different kinds of keys, their merits and demerits (2)
10. International code of Zoological nomenclature (ICZN): Operative principles, interpretation & application of important rules, formation of scientific names of taxa (3)

UNIT III

11. Theories of organic evolution; Neo-Darwinism (2)
12. Hardy-Weinberg Law of genetic equilibrium; Gene frequency and the destabilizing forces (natural selection, mutation, genetic drift, migration & meiotic drive) (3)
13. Molecular population genetics: Pattern of changes in nucleotide and amino acid sequences; Ecological significance of molecular variations (genetic polymorphism) (3)
14. Speciation: Patterns and mechanisms of reproductive isolation; Modes of speciation; Allopatry & Sympatry (2)
15. Zoo-geological time scale (2)

UNIT IV

16. Trends in evolution (2)
17. Molecular evolution: Gene evolution & Evolution of gene families (2)
18. Molecular phylogenetics: Construction of phylogenetic trees, Amino acid sequences and phylogeny (2)
19. Nucleic acid phylogeny: DNA-DNA hybridization, restriction enzyme sites, nucleotide sequence comparison and homologies (2)

Suggested Readings:

20. Kato, M. The Biology of Biodiversity. Springer.
21. Avise, J.C. Molecular Markers, Natural History and Evolution. Chapman & Hall, New York.
22. Wilson, E.O. Biodiversity. Academic Press, Washington.
23. Simpson, G.G. Principles of Animal Taxonomy. Oxford IBH Publishing Company.
24. Mayor, E. Elements of Taxonomy.
25. Wilson, E.O. The Diversity of Life (College Edition). W.W. Northem& Co.
26. Tikadar, B.K. Threatened Animals of India.ZSI Publication, Calcutta.
27. Dobzhansky, Th. Genetics and Origin of Species. Columbia University, Press
28. Dobzhansky, Th., F.J. Ayala, G.L. Stebbines and J.M. Valetine. Evolution. Surjeet Publication, Delhi.
29. Futuyama, D.J. Evolutionary Biology.Suinuaer Associates, INC Publishers, Dunderland.
30. Jha, A.P. Genes and Evolution. John Publication, New Delhi
31. Merrel, D.J. Evolution and Genetics. Holt, Rinchart and Winston, Inc.
32. Strikberger, M.W. Jones and Bartett Publisher, Boston London

CBCSZ. 402: ANIMAL ECOLOGY AND ANIMAL BEHAVIOUR

(Credits 3)

A. ANIMAL ECOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Ecosystem (Types and Structure); Energy flow circuits, Food Chain, Tropical levels and Homeostasis; Ecological Pyramids: Pyramids of number, Energy and biomass (3)
2. Ecological succession (Process, types and concept of climax); (2)
3. Interactions: inter and intra specific Relationships among animals (2)
4. Community: concept and characteristic features, Classification, Ecotone, Ecotype, Ecads and species diversity (2)
5. Laws of limiting factors (2)

UNIT II

6. Physiological ecology: introduction, the role of evolution in physiological ecology, role of models and techniques specific to physiological ecology and applications. (3)
7. Wildlife habitats, Ecological Niches and their significance (2)
8. Factors affecting wild life habitat (2)
9. Wildlife conservation: Role of legislation, administration and NGO'S (2)
10. Wildlife: Threats and their management in India (2)

B. ANIMAL BEHAVIOUR

UNIT III

11. Classification of behavioral patterns, analysis of behaviour (ethogram); Reflexes and complex behavior (2)
12. Perception of the environment: mechanical, electrical, chemical, olfactory, auditory and visual (4)
13. Homing behaviour, dispersal, host-parasite relations (3)
14. Biological rhythms: Circadian and circannual rhythms; biological clock (2)
15. Learning and memory: Conditioning, habituation, insight learning, association learning, reasoning (3)

UNIT IV

16. Reproductive behaviour. Evolution of sex and reproductive strategies, mating systems, courtship, sexual selection. parental care (4)
17. Social behaviour. aggregations, schooling in fishes, flocking in birds, herding in mammals, group selection, kin selection, altruism, reciprocal altruism, inclusive fitness (4)
18. Social Organization in insects and primates. (2)
19. Neural and hormonal control of behavior (2)
20. Genetic and environmental components in the development of behavior;(2)

Suggested Readings:

Ecology:

Krebs, C.J. **Ecology**. Harper & Row, New York.

Cherrett, J.M. **Ecological Concepts**. Blackwell Science Publication, Oxford, U.K.

Schiemdt Nielsen. **Animal Physiology: Adaptation and Environment**. Cambridge.

Kumar, H.D. **General Ecology**. Vikas publishing house Pvt. Ltd. New Delhi India.

Singh, S.P. **An Introduction to Animal Ecology**. Rastogi publications Meerut India.
Atwal, A.S. and Bains, S.S., **Applied Animal Ecology**. Kalyani Publishers. Delhi,
Ludhiana, Bhopal India.
Sharma, P.D. **Ecology and Environment**. Rastogi Publications Meerut India.
Mukherjee, B. **Environmental Biology**. Tata McGraw Hill Publishing Company Limited,
New Delhi.
Manoahan, S.E., Environmental Science and Technology. Lewis Publication, New York.
Dodson et al. Ecology.

Animal Behaviour:

Suggested Readings:

Eibl-Eibesfeldt, I.: Ethology. The biology of Behaviour. Holt, Rinehart & Winston,
New York
Gould, J.L.: The mechanism and Evolution of Behaviour.
Kerbs, J.R. and N.B. davies: Behaviourable Ecology. Blackwell, Oxford, U.K.
Hinde, R.A.: Animal Behaviour: A Synthesis of Ethology and Comparative
Psychology. McGraw Hill, New York.
Alcock, J.: Animal Behaviour: An Evolutionary approach. Sinauer Assoc. Sunderland,
Massachusetts, USA.
Bradbury, J.W. and S.L. Vehrencamp.: Principles of Animal Communication. Sinauer
Assoc. Sunderland, Massachusetts, USA
Kandel, ER, Schwartz, JH. and Jessell, T.M.: Principles of Neural science. McGraw
Hill, New York.
Brown AG.: Nerve cells and Nervous systems. Narosa Publishing house, Delhi.
Mishra.: Clinical Neuro-physiology. Churchill Livingstone
Plomin, Defries, McClearn, McGuffin: Behavioral genetics Edition 4th , WORTH
Publication, NY

ELECTIVE PAPERS

A. AQUATIC BIOLOGY AND AQUACULTURE CBCSZ 403 (A) FISHERIES AND PISCICULTURE

(No. of classes of 60 min each.)

UNIT I

1. Classification of commercially important fish fishes and shell fishes and their significance (3)
2. Fishes and shell fishes of Madhya Pradesh; Reservoir and lake fisheries (2)
3. Reverine fisheries; Estuarine and brackish water fisheries (3)
4. Marine fisheries of India (2)
5. Economic importance of fishes and their by-products (2)

UNIT II

6. Environmental factors (abiotic and biotic) in relation to life of fishes (3)
7. Exotic fishes, larvicidal fishes and their significance (3)
8. Common parasites of fishes, fish diseases, their control and treatment (3)
9. Cultivable species of inland fishes and principle of their selection (3)
10. Predatory fishes and their importance in fish culture (3)

UNIT III

11. Plankton and their importance in fish culture (2)
12. Fish ponds and their hydrobiological requirements (3)
13. Principles of genetics, hybridization and sex determination in fish (3)
14. Transgenic fish, formation and importance (2)
15. Traditional verses modern fish culture practices (2)

UNIT IV

16. Paddy cum fish culture and its significance (2)
17. Sewage fish culture and its importance (2)
18. Fish net, gears and method of fishing (3)
19. Fish preservation technology and packaging (3)
20. Marketing of fishes and role of co-operative societies (3)

CBCSZ 404 (A): AQUACULTURE

(No. of classes of 60 min each.)

UNIT I

1. Identification of stages of life histories of important cultivable fishes and prawn(3)
2. Natural breeding, bundh breeding and induced breeding of carps through hypophysation and drugs (3)
3. Planning and designing of freshwater fish farms (2)
4. Management of rearing, nursery and stocking ponds (2)
5. Transport of live fish and fish seed (2)

UNIT II

6. Planning and management of brackish-water fish farms (2)
7. Nutritional requirements of fish and artificial diet (2)
8. Freshwater aquaculture: prospects and management (2)
9. Methods of aquaculture: Pen culture, cage culture, bottom and off bottom culture (3)
10. Integrated fish farming in India : Agriculture-cum-fishery, trapa-cum-fishery, poultry-cum-fishery, piggery-cum-fishery, poultry-piggery-fishery (4)

UNIT III

11. Freshwater and Brackish water prawn culture practice in India (3)
12. Impact of aquaculture on environment: quality and quantity of waste water discharge, effect on ecosystem and degradation of soil and water (3)
13. Prospects and development of mariculture : Pearl culture, mussel culture and oyster culture (3)
14. Frog culture: Species, breeding, culture and polyculture with fish (2)
15. Prospects and development of turtle fishery (2)

UNIT IV

16. Production of Jayanti culture and seaweed culture, commercially important seaweed species and techniques of culture (3)
17. Whaling industry: Sustainable utilization (2)
18. Major aquatic resources: Export and economic status in India (3)
19. Breeding and rearing of crocodiles, crocodile industry: Indian and international Perspective (3)

Suggested Readings:

- Brown, M.E. **The Physiology of Fishes Vol.I&II.**Academic Press.
- Lagler, K.F., J.E. Bardach, R.R. Miller and D.R.M. Passino.**Ichthyology.**John Wiley & Sons, New York.
- Hoar and Randall.**Fish Physiology Vol.1-16.**Academic Press.
- Nikolsky, G.V. **The Ecology of Fishes.**Academic Press.
- Day, F. **The Fishes of India.Vol.I&II.**William Dawson & Sons Ltd. London.
- Khanna, S.S and Singh H.R. **Fish biology and fisheries.**Narendra Pub. House Delhi
- Biswas, S.P. **Fundamental of Ichthyology.**Narendra Pub. House Delhi.
- Srivastava, C.B.L. **Fishery science and fisheries** KitabMahal.
- Gary, M.R. and Sam, R.P. **Fundamentals of Aquatic Toxicology.**HemispherePub.Corp.
- Sharma, B.K. and Kaur, H. **Water Pollution** GoelPub.House.
- Santhanam, R. Ramanathan, N. and Jegatheesan, G. **Coastal Aquaculture in India** CBS Pub.

Hynes, H.B.N. **The Ecology of Running waters** Liverpool Uni. Press
Chakraborty, C. and Sadhu, A.K. **Biology Hatchery and Culture technology of Tiger prawn and giant freshwater prawn** Daya Pub. House, Delhi
Saxena, A. **Text book of Crustacea** Discovery Pub. House.
Wetzel, R. G. **Limnology Lake and Reservoir ecosystems** Academe Press.

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE CBCSZ 406 (A) Aquatic Biology and Aquaculture

- Identification of freshwater fishes, amphibians, reptiles and mammals
- Identification of common weeds, predator fishes and harmful insects
- Maintenance of fish and other aquatic animals in the laboratory
- Biometric observation of prawns, fishes, frogs, turtles and crocodile
- Estimation of length-weight relationship and condition factor of fish
- Determination of fecundity, ova diameter and maturity stages of fishes, prawns, frogs
- Identification of stages of life cycle of prawns and fishes
- Methods of induced breeding of fish through hypohysation, collection, preparation and preservation of pituitary extract, dose determination and techniques of administration
- Crafts and gears used in inland capture fisheries
- Experimental culture of phyto - and zooplanktons
- Sampling equipments of water, plankton and benthic organisms
- Statistical procedures in fishery science
- Survey of local fish farm, visit to fish seed production and fish culture UNIT-s in Gwalior, Datia, Dabra, Morena and Shivpuri
- Visit to fish landing centre, fish markets and study of fishing operations, preservation, packaging and transport
- Visit to national institutes/centres for fishery research/ survey/ education/ extension trips to Goa, Bhubneshwar, Bombay, Cochin, Barrackpore, Lucknow, Haldwani etc.
- Visit to brackish water aquaculture/prawn culture farms/centres in A.P., Kerala, CMFRI, Pawarkhera etc.
- Practical consideration to pearl culture/oyster culture
- Preparation and submission of visit/ survey/project report and charts, models and specimens

Scheme

Q.1 Identification of freshwater fishes	(8)
Q.2 biometric observations of fishes	(8)
Q.3 Estimation of length weight relationship and condition factor of fish/fecundity	(8)
Q.4 Method of induced breeding through hypophysation	(8)
Q.5 Spotting	(12)
Q.6 Viva voce	(10)
Q.7 Practical record	(6)

Total marks 60

B.CELLULAR NEUROBIOLOGY AND HUMAN GENETICS

CBCSZ 403 (B): CELLULAR BASIS OF BRAIN FUNCTION AND PATHOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Neurons as conductors of electricity, equivalent circuit representation (3)
2. Electrical properties of excitable membranes: Membrane conductance, linear and nonlinear membrane, ionic conductance, current-voltage relations (3)
3. Ion movement in excitable cells: Physical laws, Nernst-Planck Equation, active transport of ions, movement of ions across biological membranes (3)
4. Membrane potential and role of sodium and potassium pumps (2)
5. Action potential, non-gated ion channels and generation of action potential (3)

UNIT II

6. Electrical properties of neurons, quantitative models of simulations, Hodgkin & Huxley's analysis of squid giant axon: Voltage-clamp experiments; (3)
7. Synaptic transmission at nerve-muscle synapses (2)
8. Synaptic transmission at central synapses (3)
9. Mechanisms of neuroinflammation: Role of astrocytes, Schwann cells and microglia (3)
10. Neuro-AIDS (2)

UNIT III

11. Basic overview on sensory and motor systems (2)
12. Touch (3)
13. Taste (2)
14. Olfaction (2)
15. Vision (3)
16. Audition (2)
17. Pain (2)

UNIT IV

18. Cognitive development and aging (2)
19. Cellular and molecular basis of neurodegenerative disorders (3)
20. Basic systems and mechanisms of learning and memory (4)
21. Drug addiction, abuse and adverse drug reactions (3)

CBCSZ 404 (B): HUMAN GENETICS, DEVELOPMENTAL GENETICS AND CANCER

(No. of classes of 60 min each.)

UNIT I

1. Patterns of inheritance: Pedigree construction, inheritance patterns (autosomal, sex-linked, sex-limited and sex-influenced); Mitochondrial inheritance (2)
2. Complexities associated with inheritance: Penetrance, expressivity, new mutations, anticipation, imprinting, inbreeding and Consanguinity (3)
3. Introduction to genetic mapping of Mendelian traits: Two point and multipoint mapping, Lod score (2)
4. Complex or Multifactorial traits: Nature-nurture concept, Family, twin and adaptation studies, Genetic susceptibility, Threshold & Susceptibility (2)
5. Introduction to genetics mapping of complex traits: ASP and Association studies (2)

UNIT III

6. General idea of genetic basis of Monogenic disorders: (2)
 - 6.1. Autosomal (Thalasseмии)
 - 6.2. X-linked (Duchenne Muscular Dystrophy)
7. General idea on the genetic basis of metabolic and late onset disorders: (2)
 - 7.1. Phenylketonuria
 - 7.2. Alzheimer disease
8. General idea on the genetic basis of disorders due to imprinting and dynamic mutations (2)
 - 8.1. Prader Willie & Angelman syndromes
 - 8.2. Huntington disease
9. Multifactorial diseases: Molecular and biochemical basis of Diabetes mellitus (1)

UNIT III

10. Drosophila development I: Cleavage, Gastrulation and Origin of anterior and posterior polarity (maternal effect genes and segmentation genes) (3)
11. Drosophila Development II: Origin of dorsal and ventral polarity (1)
12. Basic idea of homeotic selector genes and homeotic mutations (1)
13. Basic idea of organization and evolutionary significance of homeoboxes (1)

UNIT IV

14. Differences between normal cells and cancer cells: Biochemical, cytoskeletal and cell surface changes (1)
15. General idea on the Genetic basis of human cancer; Epigenetics of cancer (chromosome instability, role of methylation & miRNAs, etc.) (3)
16. Chromosomal basis of cancer: Philadelphia chromosome (CML), Retinoblastoma, and Buerkitt's Lymphoma (2)
17. General idea of transforming agents, oncogenes and tumor suppressor genes (2)

Suggested Readings:

1. Watson, Hopkins, Roberts, Steitz and Weiner. Molecular Biology of the Gene. The Benjamin/Cummings Publishing Company Inc.
2. Bruce Alberts, Bray, Lewis, Raff, Roberts, Watson. Molecular Biology of the Cell. Garland Publishing Inc.
3. Karp, Gerald Cell Biology.
4. Lewin, B. Genes XI
5. Daniel, L., Hartl, Elizabeth W. Jones. Genetics-Principles and Analysis. Jones and Bartlett Publishers.
6. Lodish, Berk, Zipursky, Matsudaira, Baltimore, Darnell. Molecular Cell Biology. W. H. Freeman and Company.
7. Suzuki, Griffiths, Miller, Lewontin. An Introduction to Genetic Analysis. W. H. Freeman and Company.
8. Kuby, Immunology. W. H. Freeman and Company.
9. Roitt, Male, Snustad, Immunology.
10. Gardner, Simmons, Snustad. Principles of Genetics. John Wiley and Sons Inc.
11. Scott F Gilbert, Developmental Biology
12. T. Strachan & A P Read, Human Molecular Genetics 3rd Ed. Human Molecular Genetics 3, Strachan & Read, Blackwell, 2004
13. An Introduction to Molecular Human Genetics, Pasternak, Wiley,
14. Molecular Biology of the Gene, 6th Ed., Watson et al, CSH Press,
15. Human Genetics, Lewis, McGraw Hill,
16. Thompson & Thompson's Genetics in Medicine, 7th Ed, Nussbaum et al, Elsevier,
17. Foundations of Comparative Genomics, Mushegian, Elsevier,
18. Essentials of Medical Genetics, Smith
19. Human Genetics Vogel and Motulsky, Springer Verlag

Books on Neurobiology:

1. Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
2. Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007
3. Squire, Fundamental Neuroscience (4th Edition), Elsevier, 2013
4. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition), Churchill Livingstone, 2006
5. Bear, Neuroscience-Exploring the Brain (3rd Edition), Lippincott, 2007
6. Brady, Siegel, Alberts: Basic Neurochemistry: Principles of molecular, cellular and medical neurobiology. 8th Ed., Elsevier.
7. Gayton & Hall: Text book of medical physiology
8. Kiernan: Bars the human nervous system, 2015
9. Netters: Consise neurology, 2017

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

CBCSZ 406 (B) NEUROBIOLOGY AND HUMAN GENETICS

- Fluorescence localization of age pigment: lipofuscin in rat/ mice.
- Golgi technique for the demonstration of nerve fibers
- Cresyl violet staining for localization of brain cells.
- To determine pain sensitivity in rat/mice using Tail-Flick Analgesia meter
- Elevated Plus maze test with the help of Any Maze software for the anxiety and depression
- Study of learning behavior in rat by T maze and Y maze
- Study of exploratory behaviour in rat with the help of hole board apparatus and tunnel board apparatus
- Study of anatomy of human brain
- Study of the neurobehavioural reflexes in the new born rat pups such as surface righting, cliff avoidance, incisor eruption, eye opening, negative geotaxis
- Making of pedigrees (Autosomal, X-linked, Y-linked etc.)
- Complex pedigrees
- Various types of Genetic disorder (Digenetic features, Inheritance pattern & Counseling)
- PCR based detection of genetic diseases
- Study of heat shock puffs and gene activity in Chironomous.
- Study of (homeotic) Mutants of *Drosophila*.
- Study of chromosomal & cellular changes in cancer/tumor
- Demonstration of methods in epigenetic analysis
- Calculation of risk of inheritance of genetic diseases(Bayecsian calculation)

Scheme:

Q1.Experiment on neurobehaviour	(8)
Q2. Golgi technique/ Cresyl violet staining/fluorescence localization	(6)
Q3. Preparation of pedigree based on given family and diagnostic data/ Risk calculation	(8)
Q4. Genetic explanation on the given genetic disease cases/PCR-based detection of genetic disease	(8)
Q5. Spotting-8	2x8=(16)
Q6. Viva voce	(8)
Q7. Practical record	(6)

Total marks 60

C. ENDOCRINOLOGY

CBCSZ 403 (C); MALE REPRODUCTIVE ENDOCRINOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Differentiation of the testes and male genital ducts (4)
2. Histology of testes, epididymis, vas deferens and seminal vesicles (3)
3. Ultrastructure of testes (2)
4. Structure and ultrastructure of mammalian sperm (2)
5. Blood – testis barrier (3)

UNIT II

6. Hormonal regulation and Spermatogenic function of the testis (3)
7. Structure and functional significance of Sertoli cells (3)
8. Structure and functional role of Leydig cells (3)
9. Metabolism and biosynthesis of androgens (3)
10. Biochemistry of semen (2)

UNIT III

11. Maturation, transport and fate of spermatozoa in epididymis (3)
12. Capacitation of spermatozoa (2)
13. Endocrine physiology of epididymis and seminal vesicles (3)
14. Structure and function of coagulating glands, prostatic complex, Couper's gland and paraputial gland (4)
15. Inhibin and activin (2)

UNIT IV

16. Sperm motility (2)
17. Contraception through male (2)
18. Effects of environmental factors on testicular function (3)
19. Biological aspects of vasectomy (3)
20. Male infertility (2)

CBCSZ 404 (C):FEMALE REPRODUCTIVE ENDOCRINOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Differentiation of the ovary and female genital ducts (3)
2. Histology of ovary ,uterus ,cervix and vagina (4)
3. Ultrastructure of ovum (2)
4. Estrous cycle in mammals (2)
5. Menstrual cycle in primates (2)

UNIT II

6. Endocrine control of structure and function of mammalian oviduct (3)
7. Oviducalfluid :composition and physiology (3)
8. Puberty and its hormonal control (3)
9. Implantation and its hormonal regulation (3)
10. Pregnancy and its hormonal regulation (3)

UNIT III

11. Hormonal regulation of parturition (2)
12. Lactation and its regulation (3)
13. Placenta: Fine structure and types (2)
14. Placental hormones and their significance (3)
15. Corpus luteum and its functional significance (3)

UNIT IV

16. Prostaglandins and their role in reproduction (2)
17. Physiological role of ovarian steroidal hormones (3)
18. Chemistry and functions of human chorionic gonadotropin (3)
19. Delayed implantation and its mechanism (3)
20. Control of fertility in females (2)

Suggested Readings:

Turner, C.D. and J.T. Bagnara. **General Endocrinology**. W.B. Saunders.

Bentley, P.J. **Comparative Vertebrate Endocrinology**. Cambridge University Press, Cambridge, U.K.

Hadley, M.E. **Endocrinology**.

Greep, R.O. **Hand book of Physiology Vol.6: Male Reproduction**. American Physiological Society, Washington.

Greep, R.O. **Hand book of Physiology Vol.7: Female Reproduction**. American Physiological Society, Washington.

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

CBCSZ 406 (C) REPRODUCTIVE ENDOCRINOLOGY

- Dissection of various reproductive glands in vertebrates
- Operations in male rats, castration, vasectomy
- Operations in female rats, ovariectomy, hysterectomy, tubectomy; adrenalectomy, thyroidectomy, laparotomy
- Preparation of vaginal smear, identification and staining with Papanicolaou stain
- Preparation of sperm smear and classification of types of sperms with abnormalities
- Confirmation of pregnancy in urine using antibody method
- Separation of steroidal hormones; using thin layer chromatography
- Identification of permanent slides of reproductive organs
- Identification of chemical structures of steroidal hormones

Scheme

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|----|--|------------|
| 1. | Dissection of reproductive organs, accessory glands
with display and diagram. | (8) |
| 2. | Separation of steroids with TLC / pregnancy test | (8) |
| 3. | Experiments on living rats /Preparation of vaginal /sperm smear | (8) |
| 4. | Spotting- 8
(slides – 4, chemical structure – 1, electron micrographs – 3) | 2.5x8=(20) |
| 5. | <i>Viva voce</i> | (8) |
| 6. | Practical record | (8) |

Total marks 60

D. ENTOMOLOGY

CBCSZ 403 (D): INSECT TAXONOMY, ECOLOGY & DEVELOPMENT

(No. of classes of 60 min each.)

UNIT I

1. Insecta: Salient features, scheme of classification
2. Classification of Apterygota with distinctive feature, economic importance and example of various orders and their sub divisions
3. Classification of Exopterygota upto orders with distinguishing characters and examples
4. Classification of the Dictyoptera upto families with distinguishing characters, economic importance and examples
5. Classification of the Orthoptera upto families with distinguishing characters, economic importance and examples

UNIT II

6. Classification of the Hemiptera upto families with distinguishing characters, economic importance and examples
7. Classification of the Isoptera upto families with distinguishing characters, economic importance and examples
8. Classification of the Odonata upto families with distinguishing characters, economic importance and examples
9. Classification of the Thysanoptera upto families with distinguishing characters, economic importance and examples
10. Classification of Endopterygota upto orders with distinctive features and examples
11. Classification of the Lepidoptera upto families with distinguishing characters, economic importance and examples

UNIT III

12. Classification of the Diptera upto families with distinguishing characters, economic importance and examples
13. Classification of the Hymenoptera upto families with distinguishing characters, economic importance and examples
14. Classification of the Coleoptera upto families with distinguishing characters, economic importance and examples
15. Social organization in termites and honey bees

UNIT IV

16. Influence of climatic factors on insect populations
17. Adaptations of insects to their surroundings (aquatic, terrestrial and parasitic)
18. Phytophagy in insects, insect - host plant relationship
19. Structure of insect eggs, development of upto formation of germ bands; Development and fate of embryonic membranes
20. Metamorphosis in insects; Types of insect larvae and pupae; Insect diapause

CBCSZ 404 (A): APPLIED ENTOMOLOGY

(No. of classes of 60 min each.)

UNIT I

1. Beneficial insects; Role of insects in plant pollination
2. Apiculture and beekeeping
3. Lac Culture and Sericulture
4. Insects pests: Classification and categories of pests, origin and emergence of pests, pest out breaks and pest resurgence
5. Structure, life history, significance, nature of damage and control methods of pests of sugarcane : (a) Scirpophaga (b) Chilotracea (C) Pyrilla (d) Aleurolobus

UNIT II

6. Structure, life history, significance, nature of damage and control methods of following cotton pests:(a) Sylepta (b) Erias(c) Pectinophara (d) Dysdercu
7. Structure, life history, significance, nature of damage and control measures of following oil seed pests: (a) mustard aphid (b) saw fly (c) castor semilooper
8. Structure, life history, significance, nature of damage and control measures of following stored grain pests: (a) Sitophilus(b) Trogoderma(c) Rhizopertha (d) Tribolium (e) Bruchus(f) Sitotruga(g) Ephestia
9. Structure, life history, significance, nature of damage and control measures of following general pests: (a) grasshoppers & locusts (c) termites (d) aphids (e) hairy caterpillars
10. Household pests (cockroaches, crickets, ants, wasps, silverfish, cloth's moth, carpet beetle, furniture beetle, book lice, cigarettes beetles and their control

UNIT III

11. Role of insect as vectors of human diseases
12. Mosquitoes as pests of public health importance and their control.
13. Housefly: A human health hazard and its control
14. Live-stocks pests and their control
15. Different measures of insect pest control

UNIT IV

16. Detailed information and classification of insecticides and their mode of action
17. Merits and demerits of chemical insecticides and development of against them
18. Biological pest control
19. Integrated pest management
20. Account of the following: (a) Catalysts and synergists of insecticides (b) Systemic insecticides (c) Antifeedants (d) Attractants and repellents (e) Aerosols (f) Biopesticides (g) Microbiol insecticides (h) Male sterility techniques (i) IGRs, third & fourth generation pesticides (j) Chitin synthesis inhibitors

SUGGESTED READINGS

1. Richards, O.W. and R.G. Davies. **Imm'sText book of Entomology**. Methuen and Co., London.
2. Snodgrass, R.E. **Principles of Insect Morphology**. Tata MacGrawHill,s Bombay.
3. Fox, R.M. and J.W. Fox. **Introduction to Comparative Entomology**. Reinhold Publishing Corporation, New York.
4. Chapman, R.F. **The Insects – Structure and Function**. ELBS, London.

5. Nayar, K.K., T.N. Ananthakrishnan and B.V. David. **General and Applied Entomology.** Tata MacGraw Hill, New Delhi.
6. Smith, K.G.V. **Insects and other Arthropods of Medical Importance.**
7. Ross, H.H. **A Text book of Entomology.** John Wiley & Sons, New York.

LIST OF PRACTICAL EXERCISES

CBCSZ 406 (D): INSECT TAXONOMY, ECOLOGY, DEVELOPMENT & APPLIED ENTOMOLOGY

1. Insect collection and preservation for systematic studies
2. Identification of different insects upto orders
3. Identification of insects upto families of economically important insect orders
4. Identification of insects upto species: Mosquitoes, honeybees, stored grain beetles, aquatic insects, important crop and household pests
5. Analysis of honey and its quality control
6. Field studies of insects to understand their habit, habitat environmental impact, beneficial and harmful activities etc.
7. Study of beneficial insects, benefits derived from them and useful products
8. Study of destructive insects, damage caused by them and damaged products
9. Study of insecticidal formulations and insect control appliances
10. Experiments on insect control like LC-50 /LD-50, knock down and recovery effect, repellency/antifeedance tests, percentage damage tests for leaf eating insects, and stored grain pests

PRACTICAL
CBCSZ 405: TAXONOMY, EVOLUTION, ANIMAL ECOLOGY AND
ANIMAL BEHAVIOUR

1. Demonstration of natural selection under laboratory conditions by making competition between red eyed and white eyed *D. melanogaster*
2. Demonstration of Hardy-Weinberg equilibrium in human populations by taking examples of MN and ABO blood group systems
3. Study of inversion polymorphism in *Drosophila*
4. Collection, preservation and taxonomic characterization of museum specimens from different animal phyla
5. Techniques of collection, preservation, mounting and display indexing.
6. Study of evolutionary trends through models.
7. Preparation of phylogenetic tree using molecular data.
8. Problems related to evolution, population genetics.
9. Water analysis for dissolved oxygen, free carbon-dioxide, chloride, pH, hardness and alkalinity
10. Determination of climatic factors
11. Composition and classification of soil, gravel, coarse and fine sands, sand, clay-loam, loam, chalky and peaty
12. Ecological niche: A habitat study
13. Animal association and communities
14. Population dispersion
15. Structural adaptations of ecological significance.
16. Study of productivity (chlorophyll content) study of food chain and food web.
17. Experiments on **animals behaviour**:
 - 17.1 Exploratory behaviour in rats / mice
 - 17.2 Parental care in rats / mice
 - 17.3 Burrowing & geotactic behaviour of earthworms
 - 17.4 Circadian rhythmicity in foraging behaviour of honeybees
 - 17.5 T-Maze, Y-Maze
 - 17.6 Chemical communication in ants
 - 17.7 Study of comparative attraction behaviour of ants towards various type of food.
 - 17.8 Zoo visit for study of behaviour of different zoo animals/migratory birds/residential birds.

Scheme

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|--|------|
| Q.1 Exercise on evolutionary genetics & population genetics (H-W principle) | (6) |
| Q.2 Collection, preservation and taxonomic identification of vertebrate/invertebrate specimens | (8) |
| Q.3 Experiment on ecology | (8) |
| Q.4. Experiments on Animal Behavior | (8) |
| Q.5 Spotting (7) | (14) |
| Q.6 Viva voce | (10) |
| Q.7 Practical record | (6) |

 Total marks 60