

Jiwaji University, Gwalior
M.Sc. Zoology, Choice Based Credit System – 2022-24
Course Structure and Scheme of Examination

Semester	Course code	Title of Paper(s)	Course Type	Credit					
				L	T	P	Total	Marks	
FIRST	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/ Personality development/ Yoga/ Language/ Environment/Physical Education	AE & SD				1	100	
	CBCSZ -108	Seminar	AE & SD				1	100	
		Total Valid Credits						20	
		CBCSZ -109	Comprehensive viva-voce exam	Virtual credit			4	100	
	Total Credits for First Semester (Valid Credits + Virtual Credits)						24	900	
SECOND	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/ Personality development/ Yoga/ Language/ Environment/Physical Education	AE & SD				1	100	
	CBCSZ -208	Seminar-II	AE & SD				1	100	
		Total Valid Credits						20	
		CBCSZ -209	Comprehensive viva-voce exam	Virtual credit			4	100	
	Total Credits for Second Semester (Valid Credits + Virtual Credits)						24	900	
THIRD	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/ Personality development/ Yoga/ Language/ Environment/Physical Education	AE & SD	1			1	100	
	CBCSZ -308	Seminar-III	AE & SD				1	100	
		Total Valid Credits						20	
		CBCSZ -309	Comprehensive viva-voce exam	Virtual credit			4	100	
	Total Credits for Third Semester (Valid Credits + Virtual Credits)						24	900	

FOURTH	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-I	Elective C	3	0	3	100	
	CBCSZ -404	Major Elective-II	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/ Personality development/ Yoga/ Language/ Environment/Physical Education	AE & SD	1		1	100	
	CBCSZ -408	Seminar-IV	AE & SD			1	100	
	Total Valid Credits						20	
	CBCSZ -409	Comprehensive viva-voce exam	Virtual credit				4	100
Total Credits for Fourth Semester (Valid Credits + Virtual Credits)						24	900	
Total Credits for the Course (20x4=8) + (4x4=16)						96		

Major Electives

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

(A): FISH BIOLOGY AND AQUACULTURE

SEMESTER III

Code	Course	C/E/S	L	T	P	Credit	Marks
303	Fish Reproduction, Breeding and Biotechnological tools		3		0	3	100
304	Fish Physiology I		3		0	3	100
306	Fish Reproduction, Breeding and Biotechnological tools and Fish Physiology I (Practical)				3	3	100

SEMESTER IV

Code	Course	C/E/S	L	T	P	Credit	Marks
403	Inland Fishery Management		3		0	3	100
404	Fish Physiology II		3		0	3	100
406	Inland Fishery Management and Fish Physiology II (Practical)				3	3	100

(B): CELLULAR NEUROBIOLOGY AND MOLECULAR & 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): MOLECULAR ENDOCRINOLOGY AND MAMMALIAN
REPRODUCTIVE PHYSIOLOGY**

SEMESTER III

Code	Course	C/E/S	L	T	P	Credit	Marks
303	General & Molecular Endocrinology		3		0	3	100
304	Female Reproduction		3		0	3	100
306	Section A: General and Molecular Endocrinology Section B: Female Reproduction (Practical)				3	3	100

SEMESTER IV

Code	Course	C/E/S	L	T	P	Credit	Marks
403	Neuroendocrinology and Endocrine Physiology		3		0	3	100
404	Male Reproduction		3		0	3	100
406	Part A: Neuroendocrinology and Endocrine Physiology Part B: Male Reproduction (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

Minimum Number of the Credits to be earned for the award of Degree=96

*Elective courses shall be conducted as per availability of permanent faculty

* AE & SD – Ability Enhancement and Skill development

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
 - 1.3 Protozoan Parasites
 - 1.3.1 *Trypanosoma brucei*
 - 1.3.2 *Leshmaniadonavani*
 - 1.4 Helminthies Parasites
 - 1.4.1 *Schistosomahaematobium*
 - 1.4.2 *Wuchereriabancrofti*
 - 1.4.3 *Ancylostomaduodenale* (1)
 - 1.5 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
 - 9.3 Affinities
- 10. Echinodermata (2)
 - 10.1 Larval forms and their significance
 - 10.2 Water vascular system
 - 10.3 Affinities
- 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 AND
ENTOMOLOGY AND FISH BIOLOGY
(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.
 - 1.1.1 Identification of protozoan parasites form permanent slides
 - 1.2 Cnidaria: *Bougainvillea*, *Sertularia*, etc.
 - 1.3 Helminths
 - 1.3.1 Identification and characterization of helminth parasites form permanent slides
 - 1.4 Arthropoda: Cyclops, Megalopa/Zoea, spiracles of cockroach, etc.
 - 1.5 Mollusca: Glochidium larva, etc.
 - 1.6 Echinodermata: Spheredium, pedicellaria, tubefeet
 - 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. Laws of thermodynamics
 - 1.2. Free energy
 - 1.3. High-energy compounds
- 2. Carbohydrates (9)
 - 2.1. Introduction and types
 - 2.2. Glycolysis
 - 2.3. Krebs cycle
 - 2.4. Gluconeogenesis
 - 2.5 Pentose phosphate pathway
 - 2.6 Oxidative phosphorylation
 - 2.7 Glycogenesis and glycogenolysis.
 - 2.8 Carbohydrate metabolism and related disorders

UNIT-II

- 3. Lipids (5)
 - 3.1. Fatty acids: synthesis and oxidation of fatty acid
 - 3.2. Ketogenesis
 - 3.3. Metabolism of cholesterol
- 4. Lipoproteins: role in lipid transport and storage (8)
- 5. Disorders of lipid metabolism
- 6. Prostaglandins: structure and function
- 7. Structure and function of water- and lipid- soluble vitamins

UNIT-III

- 8. Hormones (2)
 - 8.1 Characteristics
 - 8.2 Mechanism of action of peptide and steroid hormones
 - 8.3 Hormone receptors and diseases (3)
- 9. Amino acids and peptides (3)
 - 9.1 Essential and non-essential amino acids
 - 9.2 Porphyrins and bile pigments
- 10 Metabolism of essential amino acids and related disorders (2)
- 11 Small peptides and their biomedical importance (1)
- 12 Structure- conformation-function relationship of proteins: Insulin, Hemoglobin and Collagen (1)
- 13. Protein folding and Protein degradation (1)

UNIT-IV

- 14. Enzymes: (5)
 - 14.1. General properties and classification
 - 14.2. Enzyme kinetics: derivation of Michaelis-Menten equation and calculations based on it & L-B plot
 - 14.3. Enzyme inhibition
 - 14.4. Mechanism of action (lysozyme & chymotrypsin)

- 14.5. Regulation of enzyme activity
15. Nucleic Acids: structure and conformations (3)
16. Nucleotide Metabolism: Synthesis and degradation of pyrimidine and purine nucleotides (3)
17. Disorders of nucleotide metabolism (2)

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 (7)
 - 7.1 Antigen processing and presentation and MHC restriction
 - 7.2 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 (6)
 - 8.1 Cell mediated cytotoxic responses
 - 8.2 Clonal selection and immunological memory
 - 8.3 Regulation of immune responses and Immunological tolerance
 - 8.4 Complement system

Unit IV

10. Human Immune system disorders (6)
 - 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 and related diseases
- 11. Immune system in human health (0)
 - 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 Mosby 1993
10. Immunology -A Short Course, Benjamin Wiley-Liss 2000
11. Text Book of Immunology, Barrett Mosby 1988
12. Biology of Microorganisms, Madigan 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
(Fixation to slide preparation) | (8) |
| 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

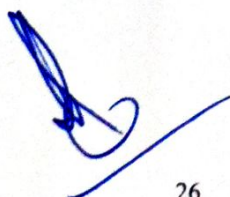
9. Formation of neural tube, differentiation of Neurons and formation of the Brain. (3)
10. Neural Crest Cells, Pattern generation in nervous system. (2)
11. Development of Eye and Cutaneous Appendages. (2)
12. Development of Heart and formation of Blood vessels. (3)
13. Development of Limbs in vertebrates. (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. hoor
10. A Text Book of Animal Physiology; R. Nagabhusnam
11. Principle of Animal Physiology; D. Moyes
12. General & comparative endocrinology; E.J.W. Barrington
13. Animal endocrinology; ManjuYadav
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



FISH BIOLOGY AND AQUACULTURE

CBCSZ- 303 (A): FISH REPRODUCTION, BREEDING AND BIOTECHNOLOGICAL TOOLS (BASED ON TELEOSTS) (Credit 3)

(No. of classes of 60 min each.)

UNIT I

- 1. Types and mode of reproduction** (2)
- 2. Gonad**
 - 2.1 Functional Morphology
 - 2.2 Oogenesis and spermatogenesis (8)
 - 2.3 Vitellogenesis and *chorionogenesis*
 - 2.4 Final oocyte maturation
 - 2.5 Role of environmental factors on gonadal development
 - 2.6 Gonadal Steroidogenesis and its control
- 7. Bisexuality and hermaphroditism** (1)
- 8. Parental care** (1)

UNIT II

- 3. Hormonal regulation of reproduction** (2)
 - 3.1 Hypothalamo-hypophysial gonadal hormones (2)
 - 3.2. Gonadotropin releasing hormones receptors in fish (2)
 - 4. Regulation and function of estrogen receptors (1)
- 5. Intra-gonadalfactors and gametogenesis** (2)
- 6. Reproductive behaviour and pheromones** (2)
- 7. Secondary sexual characters** (1)

UNIT III

- 9. Induced breeding** (8)
 - 9.1 Factors responsible for induced breeding
 - 9.2 Hypophysation
 - 9.3 Use of different synthetic and natural hormones, their formulation and mechanism of action
 - 9.4 Bundh breeding, Happa breeding, Hatchery breeding and Multiple breeding of carps
- 10. Negative accepts of breeding practices
- 11. Influences of ecological factors on maturation, spawning and hatching
- 10. *In vitro* fertilization and incubation** (1)
- 11. Fish seed collection, transport of brood fish and fish seed** (3)

UNIT IV

- 12. Fish Biotechnology** (12)
 - 12.1 Fish genetics and Hybridization**
 - 12.1.1 Gynogenesis, Androgenesis and cloned population
 - 12.1.2 Polyploidy and sterile fish
 - 12.1.3 Cryo-preservation of gametes and embryo
 - 12.1.4 Transgenic fish
 - 12.1.5 Sex reversal and breeding
 - 12.1.6 Commercial application of fish biotechnology

Books Recommended

1. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)
2. Evans: The Physiology of Fishes (2006, CRC Press)
3. Hoar & Randall: Fish Physiology, Series Vol. I – XIV (1979-2006, Academic Press)
4. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)

Books Suggested

1. Chakroff: Freshwater Fish Pond Culture and Management (1987, Scientific Publishers)
2. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)
3. Duijn: Diseases of Fishes (1967, London Iliffe Books)
4. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries Division Indian Council of Agricultural Research)
5. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
6. Howard & Churchill Canning technology (2003, London)
7. Huet: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News (1989, Books)
8. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
9. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
10. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
11. Proceedings of International Symposium on Reproductive Physiology of fishes (1982, 1987, 1991, 1995, 1999, 2003, 2007, 2011)
12. Ribelin & Migaki: The Pathology of Fishes (1975, The Univ. of Wisconsin Press)
13. Santhanam: Fisheries Science (1990, Daya Publishing House)
14. Srivastava, Gopalji: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
15. Pillay: Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)
16. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)
17. **Dunham: Aquaculture and fisheries biotechnology 2nd edition.**
18. **Induced fish breeding “A practical guide for hatcheries” by Nihar Ranjan Chatopadhyay**
19. **Hormones and their Receptors in Fish Reproduction “ World Scientific publication” Philippa Melamed Nancy Sherwood**

**CBCSZ-304 (A): FISH PHYSIOLOGY I (BASED ON TELEOSTS)
(CREDIT 3)**

(No. of classes of 60 min each.)

UNIT I

1. Integument (5)

- 1.1 Epidermis: general organization
- 1.2 Dermis: general organization of scaly and non-scaly fishes
- 1.3 chromatophores
- 1.4 functional significance of chromatophores (7)

2. Aquatic respiration

- 2.1 Gills and Mechanisms of respiration
- 2.2 Counter current principle and Respiratory pump
- 2.3 Transport of respiratory gases
- 2.4 accessory respiratory organs
- 2.5 respiration in lung fish
- 2.6 respiratory pigments

UNIT II

3. Nutrition (12)

- 3.1 Food and feeding habits of freshwater, marine water and brackish water fishes
- 3.2 Nutrient requirement (proteins, lipids, carbohydrates, minerals and vitamins) for different growth stages of freshwater carps
- 3.3 Nutritional bio-energetics
 - 3.3.1 Nutritional disorders
- 3.4 Supplementary feed and Types
 - 3.4.1 Formulation and processing, storage and quality control
- 3.5 Anti nutritional factors and their removal
- 3.6 feeding intensity
 - 3.6.1 Environmental factors influencing feeding intensity of fish

UNIT III

4. Digestion (6)

- 4.1 Alimentary canal and its modifications in relation to food and feeding habits
- 4.2 Digestion and absorption of lipid, protein and carbohydrate
- 4.3 Gastrointestinal motility control: neural and hormonal
- 4.4 Gastric enzymes

5. Circulation (6)

- 5.1 Heart and aortic arches
- 5.2 Regulation of cardiac activity
- 5.3 Hemodynamics.
- 5.4 Cardiac output
- 5.5 Circulation time
- 5.6 Blood pressure

UNIT IV

6. FINS (2)

6.1 Types and modification

6.2 Functional significance (3)

7. Swim bladder

7.1 General organization and circulation

7.2 Composition of swim bladder gas, its secretion, maintenance and removal

7.3 Functions of swim bladder (7)

8. Age and growth

8.1 Growth rate and aging

8.1.1 role of Weberianossicles and scales in age determination

8.2 Length-weight relationship

8.3 condition factor and its significance

8.4 determination of condition factor

8.5 factors influencing condition factor

Books Recommended

1. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)

2. Evans: The Physiology of Fishes (2006, CRC Press)

3. Hoar & Randall: Fish Physiology, Series Vol. I – XIV (1979-2006, Academic Press)

4. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)

Books Suggested

1. Chakroff: Freshwater Fish Pond Culture and Management (1987, Scientific Publishers)

2. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)

3. Duijn: Diseases of Fishes (1967, London Iliffe Books)

4. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries Division Indian Council of Agricultural Research)

5. Huet: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News (1989, Books)

6. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)

7. Lagler *et al.*, Ichthyology (2003, John Wiley)

8. Proceedings of International Symposium on Reproductive Physiology of fishes (1991, 1995, 1999, 2003, 2007, 2011)

9. Srivastava : Fishes of U.P. and Bihar (2002, VishwavidyalayaPrakashan)

10. Pillay: Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)

11 .Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)

PRACTICAL

FISH BIOLOGY AND AQUACULTURE

CBCSZ-306 (A): FISH REPRODUCTION, BREEDING AND BIOTECHNOLOGICAL TOOLS AND FISH PHYSIOLOGY I (CREDIT 2)

Section A: Fish Reproduction, Genetics & Biotechnology (Credit 1)

1. Determination of fecundity in major carp and catfish
2. Identification of maturity stages of gonads
2. Determination of final oocyte maturation by scoring germinal vesicle breakdown
3. Study of functional morphology of testes and ovary by preparing permanent stained slides belonging to different reproductive phases
4. Determination of gonosomatic index and their relations with regard to gonadal and body growth
5. Demonstration of induced breeding at a seed production centre
6. Visit to a fish farm and hatchery

Section B: Fish Physiology I (based on teleost) (Credit 1)

1. Dissection and display of afferent and efferent branchial vessels of a carp and a catfish
2. Study of available histological slides of kidney, liver and digestive system of a teleostean fish
3. Determination and comparison of hemoglobin content of water-breathing and air breathing fish
4. Study of ventilation rate and surfacing activity of a air-breathing fish under different experimental conditions
5. Determination of feeding habit of important edible fishes by morphological analyses of their buccopharyngeal region
6. Determination of feeding habit of carps and catfishes by analyses of their gut contents
7. Dissection display of accessory respiratory organs in teleost
8. Determination of gastrosomatic and hepatosomatic index with regards to body growth
9. Microtomy of fish material” tissue processing, Block making, Sectioning, and Staining
10. Biometric observation of fish
11. Determination of condition factors of teleost



B. CELLULAR NEUROBIOLOGY AND MOLECULAR & 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; Hybridoma technology (2)
2. Methods of protein purification and their applications (1)
3. DNA-protein interactions: Electrophoretic mobility shift assay (gel shift assay) and DNA foot printing; Chromatin immunoprecipitation (ChIP) assays, DNA pull-down assays. (3)
4. General idea of DNA micro-array (DNA chips and Affymetrix), methods and applications. (2)
5. Principles, methods and applications of DNA finger printing, RAPD and RFLP (2)

Unit II

6. Methods in analysis of gene expression: Transformation, methods of transfection and their merits and demerits; Molecular structure and properties of mammalian expression vectors. (3)
7. Methods in gene analysis: Eukaryotic promotor structure and promotor elements, Linker scanning mutation & deletion analysis, Reporter assay; Transcription factors (activators and repressors) and Enhancers. (3)
8. General idea of two-hybrid systems, Subtractive hybridization, Chromosome walking & Chromosome jumping. (2)
9. RNA analysis: RNase protection assay, Primer extension & S1 nuclease protection assay for mapping ends/of RNA transcripts (2)

Unit III

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

Unit IV

14. Introduction to Comparative genomics (*Caenorhabditis*, *Drosophila*, mouse and human) (2)
15. Approaches to transcriptome analysis (sequence and hybridization based) (2)
16. Approaches to proteomics (gel electrophoresis, Western, mass spectrometry, peptide Sequencing, gene-protein and protein-protein interactions) (2)
17. DNA methylation and DNase I Hypersensitivity in relational to gene activity and chromatin organization (2)

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
Albertes, Molecular Biology of the Cell (5th Edition) Garland Science, 2008
Kendel, Principles of Neural Science (5th edition), McGraw Hill, 2013
Verkhatsky, 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. MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

CBCSZ -303C: GENERAL & MOLECULAR ENDOCRINOLOGY

UNIT I

- 1. History and scope of endocrinology**
- 2. Environmental influences and Hormone regulations**
- 3. Endocrine integration: migration of birds and fishes; bird plumage**
- 4. Hormone like substances: Ectohormones. Phytohormones, root growth hormones**
- 5. Pheromones: Structure and functions**

UNIT II

- 6. Structural organization, hormones and hormone deficiency diseases of Endocrine systems of mammals**
 - 6.1 Pituitary gland
 - 6.2 Thyroid and Parathyroid glands
 - 6.3 Pancreas
 - 6.4 Pineal gland
 - 6.5 Adrenal glands
 - 6.6 Thymus

UNIT III

- 7. Control of hormone secretion:**
 - 7.1 Synthesis, processing and sorting of pre-prohormone precursor
 - 7.2 Sequential stages of the regulated secretory pathway
 - 7.3 Dense- cored granule exocytosis
 - 7.4 Regulation of exocytosis

UNIT IV

- 8. Hormone receptors:**
 - 8.1 Nuclear receptors:
 - 8.1.1 Structure
 - 8.1.2 Activation and recycling
 - 8.2 Membrane receptors: structure and signaling
 - 8.2.1 Enzyme-linked receptors
 - 8.2.2 Cytokine receptors
 - 8.2.3 G-protein coupled receptors
- 9. Termination of hormone action**



Books Recommended:

1. Norris and Lopez: Vertebrate Endocrinology (5th ed, Vol 5, 2011, Academic press)
2. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)
3. DeGroot and Jameson: Endocrinology (5th ed 2006, Vol 1, Elsevier-Saunders)

Books Suggested:

1. Schreibman & Pang: Vertebrate Endocrinology Vol I-IV, Fundamentals & Biomedical Implications (1985 & onwards, Academic Press)
2. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
3. Larson. Williams Textbook of Endocrinology (10th ed 2002, Saunders)
4. Norman and Litwack. Hormones (2nd ed 1997, Academic press)
5. Henson and Castracane: Leptin and Reproduction (2003, Plenum Publisher).
6. Hadley, M.C.: Endocrinology, Prentice Hall, International Edition, 2000
7. Wilson and Foster, Williams Text Book of Endocrinology 10th edition, W.B. Saunders Company Philadelphia, 2005



CBCSZ-304 C: FEMALE REPRODUCTION

(No. of classes of 60 min each.)

UNIT I

1. Differentiation of the ovary and female genital ducts	2
2. Reproductive cycles	5
2.1 Estrous cycle and Menstrual cycle	
2.2 Control of seasonal reproductive cycle	
2.2.1 Photoperiod and temperature	
2.2.2 Food supply	
3. Regulation of ovarian function	6
3.1 Follicular development and selection	
3.2 Regulation of steroidogenesis	
3.3 Oocyte maturation and corpus luteum formation	

UNIT II

3. Regulation of ovarian function	8
3.4 Mechanism of ovulation	
3.4.1 Hormonal and molecular changes during periovulatory period	
3.4.2 Factors involved in follicular rupture	
3.5 Follicular atresia	
4. Puberty and its hormonal regulation	1

UNIT III

5. Effect of endocrine disruptor, stress and ageing on female fertility	3
6. Control of fertility and sterility in female	3
6.1 Premature ovarian failure	
6.2 Polycystic ovarian syndrome	
6.3 Control of fertility in females	

UNIT IV

7. Biology of implantation	6
7.1 Cellular and molecular aspects	
7.2 Cross-talk between embryo and uterus	
7.3 Delayed implantation	
8. Placenta and its hormones	2
9. Hormonal control of pregnancy	2
10. Assisted reproductive techniques	2

Book Recommended

1. Leung and Adashi: The Ovary (2004, Raven Press)
2. Knobil & Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)

Book Suggested

1. Adashi et al: Reproductive Endocrinology, Surgery and Technology (1996, Lippincott- Raven publishers)
2. Findlay: Molecular Biology of the Female Reproductive System (1994, Academic Press)
3. Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.
4. Lamming: Marshall's Physiology of Reproduction (1984, Longman)
5. Strauss and Barbieri: Yen and Jaffe's Reproductive Endocrinology (6th Ed. Saunders, 2009).
6. Turner, C.D. and J.T. Bagnara. General Endocrinology. W.B. Saunders.
7. Bentley, P.J. Comparative Vertebrate Endocrinology. Cambridge University Press, Cambridge, U.K.
8. Hadley, M.E. Endocrinology.
9. Greep, R.O. Hand book of Physiology Vol.6: Male Reproduction. American Physiological Society, Washington.
10. Greep, R.O. Hand book of Physiology Vol.7: Female Reproduction. American Physiological Society, Washington.



PRACTICALS

CBCSZ 306 D: (CREDIT 2)

SECTION A: GENERAL AND MOLECULAR ENDOCRINOLOGY (CREDIT 1)

1. Dissection of endocrine glands in invertebrate and vertebrates (cockroach, grasshopper, fish and rat)
2. Determination of proteins, /cholesterol/ sugar level using spectrophotometer
3. Study of exocytotic cycle by photomicrographs
4. Effect of thyroxin on serum glucose, creatinine and LDH
5. Estrogen bioassay in female rat
6. Biochemical estimation of SOD and catalase activity
7. Identification of chemical structures of peptides and steroid hormones
8. Estimation of hormones in blood
9. Microtomy of endocrine material (tissue fixation, processing, paraffin block preparation, sectioning, staining and mounting)

Section B: Female Reproduction (Credit 1)

1. Studies on permanent slides of female reproductive organs (ovary, uterus, oviduct and vagina)
2. Study of permanent slides of different endocrine glands
3. Hysterectomy
4. Induction of PCOS condition in rat
5. Study of rat oestrous cycle using vaginal smear preparations
6. Isolation of large antral follicle and corpus luteum
7. Isolation of egg, granulosa and theca cells
8. Demonstration of ovarian proteins by 2-D Gel electrophoresis

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

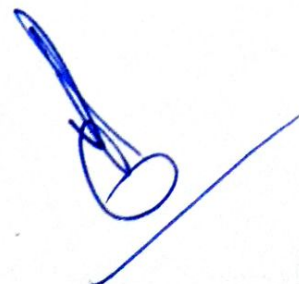
UNIT IV

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: Sustainibility& Management of Aquaculture & Fisheries.
Arugun&Natarajan: Fresh water Aquaculture.
Arugun&Natarajan: Santanu-Costal Aquaculture.
R.Sanatham: A manual of fresh water Aquaculture.

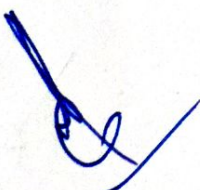


LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

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 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. Stebbins 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 (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:

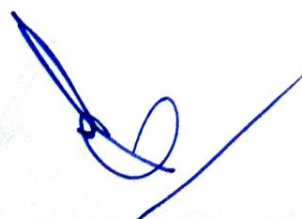
Ecology:

- 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.
Manohaana, 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, Massachsets, USA.
Bradbury, J.W. and S.L. Vehrencamp.: Principles of Animal Communication. Sinauer Assoc. Sunderland, Massachsets, 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

FISH BIOLOGY AND AQUACULTURE CBCSZ-403 (A) INLAND FISHERY MANAGEMENT (CREDIT 3)

(No. of classes of 60 min each.)

UNIT I

1. Fishery resources of India (12)

1.1 Inland fisheries

1.1.1 Riverine fishery: regulation and exploitation, river pollution, dams and their effect on fish migration

1.1.2 Lacustrine fishery: management, development and exploitation

1.1.3. Marine fishery: management, development and exploitation

1.1.4. Estuarine Fishery: management, development and exploitation

2. Cold water fishery in India: management, development and exploitation

3. Hill stream fishes

UNIT II

4. Fish culture systems (12)

4.1 Ponds

4.1.1 Fish farm: Lay out and construction of different types of ponds

4.1.1.1 Formulation and operation of different types of hatcheries

4.1.1.2 Hatchery management and hatchery breeding

4.1.1.3 Brood pond management for cultivable indigenous and exotic carps

4.1.2 Pond management: stocking, rearing and nursery pond

4.1.2.1 Physico-chemical properties of pond water and soil, and their maintenance

4.1.2.2 Manuring (organic and inorganic) and liming

4.1.2.3 Composite fish farming and polyculture

4.2 Other systems: cage, raft, pens, raceways

UNIT III

5. Inland fishing gears and fishing methods (3)

5.1 Types of fishing gears

5.2 Preparation and maintenance of fishing nets

6. Fish pathology, prophylaxis and therapy (6)

6.1 Protozoan diseases: Cyclochaetiasis, Costiasis (sliminess of skin)

6.2 Helminth parasites: *Gyrodactylus*, *Dactylogyrus*

6.3 Crustacean parasites: *Ergasilus*, *Lernaea*

6.4 Fungal diseases: branchiomycosis (gill rot), Saprolegniasis

6.5 Bacterial diseases: tail and fin rot, furunculosis

6.6 Viral diseases: papillomatosis (cauliflower disease), dropsy

6.7 Channel cat fish disease and its control measure

7. Chemical composition and nutritional value of fish (3)

8. Fish by-products: production and utilization

UNIT IV

9. Fish preservation and packaging

(12)

10. Fish marketing and role of cooperative societies in fish marketing

11. The economics of fisheries

12. Exploitation and other threats to fish conservation

13. Fisheries legislation for resources management

14. Recreational fishing

15. Fish in relation to human health

16. Fish aquarium and its maintenance

Book Recommended

1. Bond: Biology of Fishes (1979, Saunders)
2. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
3. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
4. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
5. NIIR Board of consultants and engineers: handbook on fisheries and aquaculture technology {Asia Pacific business Press Inc.}
6. Hart and Reynolds: Handbook of fish biology and fisheries volume 2, {blackwell publishing}.



FISH BIOLOGY AND AQUACULTURE

CBCZ-404 (A): FISH PHYSIOLOGY II (BASED ON TELEOSTS) (CREDIT 3)

(No. of classes of 60 min each.)

UNIT I

1. Nervous system & Receptors (12)

- 1.1 Anatomy and physiology of central nervous system
- 1.2 Autonomic nervous systems
- 1.3 The pineal organ
- 1.2 Receptors
 - 1.2.1 Eye: structure, photoreception, formation of image, functional adaptations
 - 1.2.2 Acoustico-lateralis system: labyrinth, lateral line organs
 - 1.2.3 Chemoreceptors: gustatory, olfactory, electroreceptors
- 2. Anthropogenic impacts on behaviour and physiology

UNIT II

3. Endocrine system (12)

- 3.1 Hypothalamo-hypophyseal system:
 - 3.1.1 Organization of a typical teleost hypothalamus and neurosecretions
 - 3.1.2 Functional morphology of pituitary and hypophyseal hormones
 - 3.1.3 Hypothalamic control of pituitary
- 3.2 Osmoregulatory hormones
- 3.3 Hormones in growth and metabolism

UNIT III.

4. Excretion, osmoregulation and homeostasis (12)

- 4.1 Glomerular and a glomerular kidneys
- 4.2 Excretion of nitrogenous wastes, water and ion balance
- 4.3 osmoregulation in fishes
- 4.4.pH regulation in fresh water and sea water fishes
- 4.5 Stress sensing to homeostasis
 - 4.5.1 osmosensors
 - 4.5.2 signal transduction to sensors
- 4.6 managing stress in fish

UNIT IV.

5. Immunology of fish (12)

- 5.1. Introduction: Types of immunity
 - 5.1.1 Effects of stressors on the immune response
 - 5.1.2 Effects of hormones on the immune system
 - 5.1.3 Environmental stressors and fish immunity
- 6. Muscles Physiology
 - 6.1 Structure and function of fish muscles
 - 6.2 Muscle fibre types
 - 6.3 Hormonal regulation of muscle growth

Books Recommended

1. Bentley: Comparative Vertebrate Endocrinology (2000, Cambridge University Press)
2. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)
3. Evans: The Physiology of Fishes(2006, CRC Press)
4. Hoar & Randall: Fish Physiology, Series Vol. I – XIV (Academic Press)
5. biology of stress in fish volume 35 first edition, Carl B.Schreck, et al.,

Books Suggested

1. Gorbman et al: Comparative Endocrinology (1978, John Wiley)
2. Hadley: Endocrinology Prentice Hall (2011, International Editions)
3. Norris: Vertebrate Endocrinology (2nd ed 2009, Academic Press)
4. Bond: Biology of Fishes (1979, Saunders)
5. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
6. Hughes: Comparative Physiology of Vertebrate Respiration, Heinemann Educational (1967, Books)
7. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
8. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)
9. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
10. Singh: Advances in Fish Research, Vol. I and II (1993 and 1997, Narendra Publishing House)
11. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)

PRACTICALS

FISH BIOLOGY AND AQUACULTURE

CBCSZ-406 (A): INLAND FISHERY MANAGEMENT AND FISH PHYSIOLOGY II (CREDIT 2)

Section A: Inland fishery management (Credit 1)

1. Seasonal analyses of pond water by measuring the following physico-chemical properties:

1.1 Transparency, water temperature, turbidity, depth, pH, Dissolved O₂ contents, free carbondioxide, total alkalinity, total hardness, chloride, calcium, magnesium, nitrate, phosphate, silicate.

2. Identification of locally available fishes of economic importance

3. Crafts and gears used in inland capture fishery.

4. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation.

5. Estimation of protein content in muscle/liver of fresh and preserved fish

Section B: Fish Physiology II (based on teleosts) (Credit 1)

1. Preparation of permanent stained slides of different endocrine glands and kidney of *Heteropneustes fossilis* / *Clarias batrachus*

2. Survey of different endocrine glands

3. Dissection and display of different parts of brain

4. Dissection and display of cranial nerves of *Mystus Wallago* / *Clarias*

7. Study of various fish diseases and their treatment (Protozoans/Helminthes/ Fungal / Viral /Bacterial and Nutritional)

B.CELLULAR NEUROBIOLOGY AND MOLECULAR & 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, 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. Pedigree: Collection of pedigree data, Pedigree signs and Pedigree construction. (2)
2. Analysis of inheritance patterns of Mendelian diseases I: Autosomal, sex-linked, sex-limited and sex-influenced diseases; Mitochondrial inheritance. (2)
3. Analysis of inheritance patterns of Mendelian diseases II: Complexities associated with Mendelian pedigrees (inheritance) in reference to penetrance, expressivity, new mutations, anticipation, imprinting, inbreeding and Consanguinity. (3)
4. General idea of genetic basis of Monogenic disorders: Alpha and beta thalassemia, Muscular dystrophy (BMD and DMD) (2)

Unit II

5. General idea on the genetic basis of Prader Willie & Angelman syndromes and Huntington disease. (2)
6. General idea on the genetic basis of metabolic and late onset disorders, like Phenylketonuria and Alzheimer's disease. (2)
7. Molecular and biochemical basis of diabetes mellitus and cardiac diseases. (2)
8. Genetics of human behavior: Schizophrenia and other mental disabilities (e.g., fragile x-syndrome, Down's syndrome, etc.). (2)

Unit III

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

Unit IV

13. Differences between normal cells and cancer cells: Types of biochemical, cytoskeletal and cell surface changes in cancer cells; Properties of cancer cells (migration and invasion). (2)
14. General idea of transforming agents, oncogenes and tumor suppressor genes (3)
15. Genetic and epigenetic basis of human cancer (gene mutations, chromosome instability, role of methylation & miRNAs); metastasis (2)
16. Chromosomal basis of cancer: Philadelphia chromosome (CML), Retinoblastoma, and Buerkitt's Lymphoma (2)

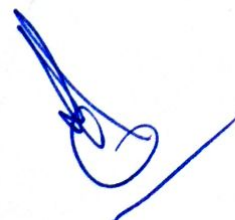


Suggested Readings:

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(Bayesian 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

CBCSZ-403 (C): NEUROENDOCRINOLOGY AND ENDOCRINE PHYSIOLOGY

UNIT I

- 1. Neurosecretion and neuroendocrine mechanisms in non-arthropod invertebrates (4)**
- 2. Neuroendocrine system in Crustacea and Insecta (3)**
- 3. Neuroendocrine system in Mollusca and Caudal neurosecretory system in fish (3)**
- 4. Role of hypothalamus and neuroendocrine integration in mammals (2)**

UNIT II

- 5. Hypophysiotropic hormones: Localization, mechanism of action and regulation of secretion of, (10)**
 - 5.1 TRH
 - 5.2 GnRH
 - 5.3 Somatostatin
 - 5.4 CRH
 - 5.5 GHRH and PACAP

UNIT III

- 6. Neurohormone melatonin (4)**
 - 6.1 Localization and secretion
 - 6.2 Mechanism of action
 - 6.3 Biological action
 - 6.4 Sleep disorders and jet lag
- 7. Neuropeptides: Localization, mechanism of action and regulation of secretion of, (5)**
 - 7.1 Oxytocin
 - 7.2 Vasopressin

UNIT IV

- 8. Insulin and insulin like peptides and their role in early mammalian development. (2)**
- 9. Renin and Angiotensins and their functional significance (3)**
- 10. Gastrointestinal hormones and their physiological significance (3)**
- 11. Biochemistry and functional significance of sex steroids (3)**

Books Recommended

1. Bolander: Molecular Endocrinology (3rded 2006, Elsevier)
2. DeGroot and Jameson: Endocrinology (5thed 2006, Vol 1, Elsevier-Saunders)

Books Suggested

1. Norris and Carr: Vertebrate Endocrinology (5thed, Vol 5, 2011, Academic press)
3. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
4. Larson. Williams Textbook of Endocrinology (10thed 2002, Saunders)
5. Norman and Litwack. Hormones (2nded 1997, Academic press)

CBCSZ-404 (C): MALE REPRODUCTION

(No. of classes of 60 min each.)

UNIT I

1. Differentiation of testis and male genital duct (3)
2. Blood-testis barrier (1)
3. Biochemistry of Semen (1)
4. Effects of environmental factors on testicular function (2)
5. Ultrastructure of testis and mammalian sperm (3)

UNIT II

6. Testis (10)
 - 6.1 Spermatogenesis and hormonal regulation
 - 6.2 Oxidative stress and spermatogenesis
 - 6.3 Sertoli cell biology
 - 6.4 Leydig cell formation, function and regulation
 - 6.5 Cell-cell interactions in control of spermatogenesis

UNIT III

7. Epididymis: structure, function and regulation (4)
8. Male accessory sex glands: structure, function and regulation (4)
9. Environmental toxicants and male reproduction (3)
10. Male sterility (5)
 - 10.1 Parameters of male sterility
 - 10.2 Origin and cause of male sterility
 - 10.2.1 Azoospermia
 - 10.2.2 Oligozoospermia
 - 10.2.3 Varicocoele
 - 10.2.4 Cryptorchidism

UNIT IV

11. Sexual behaviour (5)
 - 11.1 Copulatory patterns
 - 11.2 Hormones in sexual behavior
 - 11.3 Control by brain centres
12. Reproductive pheromones (4)
 - 12.1 Pheromones in regulation of estrous cycle, puberty and pregnancy
 - 12.2 Sites of action of pheromones
 - 12.3 Human reproductive pheromones

Book Recommended

1. Adashi et al: Reproductive Endocrinology, Surgery and Technology (1996, Lippincott-Raven publishers)
2. Knobil & Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)

Books Suggested

1. Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.
2. Lamming: Marshall's Physiology of Reproduction (1984, Longman)
3. Mann & Lutwak-Mann: The Male Reproductive Function and Semen (1998, Springer)
4. Paulson et al: Andrology: Male Fertility and Sterility (1986, Academic Press)
5. Setchell: The Mammalian Testis (1992, Cornell University Press)
6. Yen et al: Reproductive Endocrinology (1999, Saunders)
7. Singh, Shio Kumar: Mammalian endocrinology and male reproductive biology (2016, CRC Press/Taylor & Francis group).

PRACTICALS**CBCSZ 406 (C) : (CREDIT 2)****PART A: NEUROENDOCRINOLOGY AND ENDOCRINE
PHYSIOLOGY AND MALE REPRODUCTION (CREDIT 1)**

1. Study of pituitary and pineal cell types through prepared slides
2. Hypothalamic centres (SON, PVN, AR) anatomical observation in brain slices
3. Ascorbic acid depletion bioassay for LH
4. Hormone estimation by ELISA
5. Immuno-localization of hormone receptor in rat hypothalamus
6. Immunoblot analysis of GnRH receptor in rat hypothalamus during different phases of oestrous cycle
7. Separation of steroidal hormones; using thin layer chromatography
8. Identification of permanent slides of reproductive organs
9. Study of permanent slides of reproductive organs: testis, epididymis (caput, corpus, and cauda), seminal vesicle and prostate
10. Study of spermatogenic cycle using histological slides of testis
11. Cryptorchidism and vasectomy in rat
12. Study of sperm motility, morphology, and count in rat
13. Effect of endocrine disrupting chemical on steroidogenic enzyme gene expression
14. Preparation of sperm smear and classification of types of sperms with abnormalities
15. Identification of chemical structures of steroidal hormones

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's Text 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

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

