

Syllabus for M. Sc. Zoology (Semester with credit based Pattern) w e f 2012-13 Academic session

The syllabus for M. Sc. Zoology based on semester with credit based pattern comprises of four semesters. The examination shall be of 16 (Sixteen) theory papers each of 100 marks. Each paper is equivalent to 4 credits hence total credits of 16 theory papers are 64 (16x4=64). There shall be seven practicals and a project work of 100 marks each, equivalent to the total 32 credits (7 practicals x 4 =28 + a project work x 4= 4). The Examination in each theory paper shall be of three hours duration and that of each practical shall be of 6 hours. The seminar shall be conducted during the First, Second, Third and Fourth semester. Each seminar shall be of 25 marks equivalent to 1 credit (4 seminars x1= 4 credits). At the end of Fourth semester candidate has to submit a Project work. The project work shall be of 100 marks. Candidates are expected to pass separately in seminar, theory, project and practical examination. The work load for each theory paper shall be of 4 clock hours per week. Work load for each practical shall be of 8 clock hours per week. Two clock hours per week will be devoted to seminar. Eight (08) clock hours per week will be devoted to project work. In IV semester, project work is compulsory for all the students. The structure of syllabus for M. Sc. Zoology (Semester with credit based pattern) is also displayed in the following Table 1 and 2.

Table -1

Semester with credit based pattern for M. Sc. Zoology

Semester	Theory (T) Papers & Marks/ Practical (P) & Marks/ Seminar (S)/Project	Credit	Total Marks/ Credit	Grand total Marks & credit
I	T-4 X 100 = 400 P-2 X 100 = 100 S-1 X 25 = 25	4 X 4 = 16 2 X 4 = 08 1 X 1 = 01	625/25	2500 marks 100 credits
II	T-4 X 100 = 400 P-2 X 100 = 100 S-1 X 25 = 25	4 X 4 = 16 2 X 4 = 08 1 X 1 = 01	625/25	
III	T-4 X 100 = 400 P-2 X 100 = 100 S-1 X 25 = 25	4 X 4 = 16 2 X 4 = 08 1 X 1 = 01	625/25	
IV	T-4 X 100 = 400 P-1 X 100 = 100 S-1 X 20 = 25 Project = 100	4 X 4 = 16 1 X 4 = 04 1 X 1 = 01 1 X 4 = 04	625/25	

Table -2. M. Sc. Zoology syllabus, semester with credit based pattern (Theory)

Semester	Paper	Title of paper	Work load hours/week	Marks	
I	I	Structure and Function of Invertebrates	4	100	
	II	General Physiology	4	100	
	III	Cell Biology and Genetics	4	100	
	IV	Advance Reproductive Biology	4	100	
II	V	Structure and Function of Vertebrates	4	100	
	VI	Comparative Endocrinology	4	100	
	VII	Molecular Biology and Biotechnology	4	100	
	VIII	Advance Developmental Biology	4	100	
III	IX	Parasitology	4	100	
	X	Immunology	4	100	
	XI	Special Group- Paper-I	Entomology	4	100
			Fish and Fisheries		
			Mammalian Reproductive Physiology (MRP)		
			Animal Physiology		
			Cell Biology		
			Fresh Water Zoology		
			Aquaculture		
	XII	Special Group- Paper-II	4	100	
	IV	XIII	Biotechniques, Biostatistics and Ethology	4	100
XIV		Toxicology and Bioinformatics	4	100	
XV		Special Group- Paper-III	Entomology	4	100
			Fish and Fisheries		
			Mammalian Reproductive Physiology (MRP)		
			Animal Physiology		
			Cell Biology		
			Fresh Water Zoology		
			Aquaculture		
XVI		Special Group- Paper-IV	4	100	
IV	XVI	Entomology	4	100	
		Fish and Fisheries			
		Mammalian Reproductive Physiology (MRP)			
		Animal Physiology			
		Cell Biology			
		Fresh Water Zoology			
		Aquaculture			
		Environmental Biology			
		Sericulture			
		Sericulture			

M. Sc. Zoology syllabus, semester with credit based pattern (Practical)

Semester	Practical	Hours/Week	Marks
I	Seminar-I	02	25
	Practical-I	08	100
	Practical-II	08	100
II	Seminar-II	02	25
	Practical-III	08	100
	Practical-IV	08	100
III	Seminar-III	02	25
	Practical-V	08	100
	Special Group-Practical-VI	08	100
IV	Seminar-IV	02	25
	Special Group-Practical-VII	08	100
	*Project work	08	100

* The examinee shall be required to produce at the practical examination the following:

The two typed copies of project work signed by supervisor and certified by the Head of the Department/ Principal as a bonafide work of the examinee shall be submitted at least one month prior to the commencement of the practical examination. The project shall comprise of Introduction, Materials and Methods, Results, Discussion, Summary and References along with the declaration by the candidate that the work is original and not submitted to any University for the award of the Degree and certified by the supervisor. The evaluation of the project work shall be held on the day of practical by the external and internal examiners and the marks will be submitted to the University as project marks. The subject of project shall be given to a group of not more than four students or to a single student independently on any topic from Life Sciences.

Study tour is to be undertaken in the Semester- I and –III.

Semester-I

Paper-I, Structure and function of Invertebrates

Unit-I

- 1.1 Classical and molecular taxonomic parameters, species concept, systematic gradation of animals, nomenclature, modern scheme of animal classification into sub-kingdom, division, section, phyla and minor phyla.
- 1.2 Ultrastructure of protozoan locomotory organs (pseudopodia-cytoplasmic organells, flagella, cilia and pellicular myonemes) and mechanism of various modes of locomotion.
- 1.3 Dermal cells and skeletal organization in calcareous sponges, Hexactinilida and Demospongiae (Porifera).
- 1.4 Formation, evolution and significance of coelom, metamerism and symmetry in classification of animals, particularly coelomata.

Unit-II

- 2.1 Origin of metazoan-colonial, syncytial and molecular theories.
- 2.2 Polymorphism and metagenesis in Coelenterata. Types of polyps, medusa and metamorphosis.
- 2.3 Reproductive system-structure and mechanism of reproduction in *Dugesia*, *Fasciola*, *Taenia* and *Ascaris*.
- 2.4 Evolution of nephridia and mechanism of excretion (nitrogenous excretory products, transport of water and salts) in Polychaeta, Oligochaeta and Hirudinea of Annelida.

Unit-III

- 3.1 *Peripatus* (Onychophora) structure, affinities and taxonomic position.
- 3.2 Respiratory organs in Arthropoda. Mechanism of gaseous exchange in tracheal respiration in Insecta and gill respiration in Crustacea.
- 3.3 *Neopilina* (Monoplacophora): structure, affinities and taxonomic position.
- 3.4 Neuroanatomy in Gastropoda, Bivalvia and Cephalopoda.

Unit-IV

- 4.1 Water vascular system in Echinodermata: structure and functions.
- 4.2 Larval forms in Echinodermata: Metamorphosis and phylogenetic significance.
- 4.3 General account and affinities of Ctenophora and Rotifera.
- 4.4 General account and affinities of Entoprocta and Ectoprocta.

Semester-I

Paper-II, General Physiology

Unit-I

- 1.1 Enzyme: Classification, mechanism of enzyme action. Factors affecting enzyme action, regulation of enzyme activity, activators and inhibitors.
- 1.2 Respiratory pigments- types, distribution and properties, structure of haemoglobin and mechanism of O₂ transport.
- 1.3 Neurotransmitters: chemical nature, biosynthesis and mechanism of synaptic transmission.
- 1.4 Colour change mechanism: Chromatophores and melanophores- structure, physiology and significance.

Unit-II

- 2.1 Bioluminescence: light producing organs- distribution in invertebrates and vertebrates, physiology and significance.
- 2.2 Thermoregulation in poikilotherms and homeotherms, adaptations and regulatory mechanisms.
- 2.3 Osmoregulation in Pisces and Amphibia, mechanism of salt and water transport by gills and kidney.
- 2.4 Molecular mechanism of peptide and steroid hormonal action. Membrane receptors and signal transduction.

Unit-III

- 3.1 Myogenic and neurogenic heart, Cardiac cycle- Phases of cardiac cycle, ECG pace maker, and heart valves.
- 3.2 Digestion and absorption of carbohydrate, proteins and lipids in the gastrointestinal tract.
- 3.3 Carbohydrates- classification and metabolism- glycogenesis, glycogenolysis, glycolysis, TCA cycle, electron transport system and oxidative phosphorylation.
- 3.4 Lipids- classification and metabolism- oxidation of fatty acids, cholesterol metabolism. Proteins- classification and metabolism- oxidative deamination, decarboxylation and trans amination of amino acids, arginine-ornithin cycle.

Unit-IV

- 4.1 Hydromineral metabolism-water electrolyte balance, mineral metabolism in bone and egg shell formation.
- 4.2 Cerebrospinal fluid: Chemistry and functions.
- 4.3 Mechanism of reflex action.
- 4.4 Physiology of environmental stress and strain- tolerance, avoidance, resistance and physiological adaptations.

Semester-I

Paper-III, Cell Biology and Genetics

Unit-I

- 1.1 Membrane structure and function - structure of model membrane, lipid bilayer, membrane protein diffusion, osmosis, active transport, uniport, multiport, symport, antiport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
- 1.2 Structural organization and functions of cell organelles- nucleus, mitochondria, endoplasmic reticulum, Golgi complex, lysosomes and peroxisomes.
- 1.3 Structure and Functions of microfilaments, microtubules and their role.
- 1.4 Cell division and cell cycle - phases of cell cycle, checkpoints of cell cycle, regulation of cell cycle, mitosis, meiosis.

Unit-II

- 2.1 Cell signaling - hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, Receptor protein- tyrosin kinase and ion channel receptors.
- 2.2 Signal transduction pathways, primary and secondary messenger systems, regulation of signaling pathways.
- 2.3 Cellular communication - general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix and integrins.
- 2.4 Cancer - genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis.

Unit-III

- 3.1 Mendelian, non-Mendelian inheritance - mono / dihybrid inheritance, types of dominance, multiple allelism, probability, exercises for solving genetics problems.
- 3.2 Extensions of Mendelian principles - codominance, incomplete dominance, gene interactions, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
- 3.3 Quantitative Genetics - polygenic traits and mode of inheritance, analysis of variation, genetic and environmental factors, heritability, inbreeding and consequences, co-efficient of inbreeding and consanguinity.
- 3.4 Mutation - types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants.

Unit-IV

- 4.1 Structural and numerical alterations of chromosomes - deletion, duplication, inversion, transversion, translocation, ploidy and their genetic implications.
- 4.2 Extra chromosomal inheritance - cytoplasmic inheritance, inheritance of mitochondrial genes, maternal inheritance.
- 4.3 Microbial genetics - recombination in bacteria and gene mapping, transformation, conjugation, transduction (generalized and specialized), fine structure mapping of genes.
- 4.4 Human genetics- pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Semester-I

Paper-IV, Advance Reproductive Biology

Unit-I

- 1.1 Various methods of asexual and sexual reproduction in Protozoa.
- 1.2 Regeneration in *Hydra*, *Dugesia* and Annelid worms; Morphogenesis and hormonal control.
- 1.3 Metamorphosis in insects: Partial and complete metamorphosis, metamorphic forms- nymph, larvae and pupae.
- 1.4 Mechanism of vitellogenesis in insects.

Unit-II

- 2.1 Spermatogenesis: Process, hormonal control and ultra-structure of spermatozoa of man.
- 2.2 Mechanism of oogenesis: Process, biochemical events, hormonal regulation.
- 2.3 Cytological and molecular events of fertilization.
- 2.4 Types of cleavage, blastulation, gastrulation and embryonic induction.

Unit-III

- 3.1 Male accessory sex glands in mammals: structure, secretion and functions.
- 3.2 Semen- biochemical composition and sperm abnormality.
- 3.3 Sperm capacitation and decapacitation- molecular mechanism and significance.
- 3.4 Pheromones and sexual behavior in mammals.

Unit-IV

- 4.1 Neurohormonal control of fish reproduction and mechanism of vitellogenesis.
- 4.2 Molecular induction (Morphogenetic gradients) and organizer concept.
- 4.3 Cryopreservation of gametes, embryo and test-tube baby.
- 4.4 In vitro fertilization (IVF) and its significance.

Semester I, Practical-I, Structure and Function of Invertebrates and General Physiology

Section-A

1. Study of museum specimens.

Classification up to order and comments on the specimens representing all phyla.

2. Dissection (Any available animal)

- Digestive system – Earthworm, Leech, Cockroach. Silkworm, Honey bee
- Nervous system – Prawn, Cockroach. Silkworm, Honey bee
- Reproductive system- Earthworm, Leech, Cockroach, Honey bee.

3. Mounting

- Earthworm – Nerve ring, ovary, spermatheca, nephridia.
- Leech – jaws, ciliated organ.
- Cockroach – Mouth parts, Salivary glands, trachea.
- Prawn – Appendages, Statocyst.
- Protozoans- rhizopods , flagellates , ciliates (fresh water forms).
- Porifera – Spicules and gemmules of fresh water sponges.
- Crustaceans and rotifers - Planktonic copepodes, cladoceran, ostracoderm and rotifers.
- Larval forms of the free living invertebrates.
- Larval forms of parasitic invertebrates.

Note: Student should prepare and submit at least 10 permanent stained micropreparation.

4. Study of permanent Invertebrate slides

- Porifera – T.S. and L.S. of *Sycon*, gemmules, spongian fibres, spicules
- Coelenterata – T.S. of *Hydra* , T.S. of Sea anemone, Ephyra larva
- Helminths – T.S. of *Planaria*, T.S. of *Taenia* , scolex W.M., Mature , gravid proglotids , T.S. of male and female *Ascaris*, W.M of *Ankylostoma* , *Enterobius*, *Dracunculus*, *Wuchereria*
- Annelida -T.S. of *Nereis*, T.S. of Earthworm passing through various organs, T. S. of Leech.
- Arthropod larvae – Nauplius, Zoea, Metazoea, Megalopa, Mysis.
- Mollusca – T.S. of foot, Veliger and Glochidium larva.
- Echinodermata- pedicellariae, T.S. of arm of star fish, Bipinnaria, Oricularia larva .
- Hemichordata – T.S. through collar, proboscis, trunk and branchio-genital regions. Tornaria larva.

Note: Students should prepare at least 10 permanent stained micropreparations.

Section-B

1. Physiology experiments –

- Total leucocyte count and differential leucocyte count
- Total R.B.C. count.
- Demonstration of action of salivary amylase, trypsin, pepsin.
- Demonstration of rate of O₂ consumption in aquatic animals, under various environmental stresses.

- e) Demonstration of haemoglobin concentration in normal and pathological condition.
- f) Estimation of sodium, potassium and chloride in blood and excretory organs by Colorimeter or flame photometer.
- g) Estimation of glucose in blood by spectrophotometer or Colorimeter.
- h) Estimation of total blood proteins by spectrophotometer or Colorimeter.
- j) Estimation of cholesterol in blood by spectrophotometer or Colorimeter.

Distribution of Marks:	Marks
Dissection:	10
Stained permanent preparation:	05
Identification and comment on the spots (1-10)	20
Physiology experiment (Major)	15
Physiology experiment (Minor)	10
Submission of stained permanent slides	05
Class Record	10
Viva-voce	05

	80
Internal Assessment	20

Total marks	100

Semester-I, Practical-II, Cell Biology, Genetics and Advance Reproductive Biology

Section-A

1. Study of mitotic metaphasic chromosomes in plant material/ cultured animal cells/cleaving eggs of invertebrate/vertebrate.
2. Preparation of human karyotypes by using photographs/pictures.
3. Demonstration of Barr body in human female leucocytes.
4. Demonstration of polytene chromosome in dipteran larvae.
5. Problems on genetics based on monohybrid/dihybrid ratios, sex linked inheritance and blood groups
6. Study of various human genetic traits

Section-B

1. Study of meiotic chromosomes and spermatogenesis in grasshopper/rat.
2. Demonstration of oogenesis in earthworm/fish/rat ovary.
3. Semen analysis: physical viscosity, pH, liquefaction time, agglutination test, motility and sperm count in human.
4. Sperm vitality study using suitable stains.
5. Hypo-osmotic swelling (HOS) for the assessment of normal semen.
6. Study of vaginal smear in rat by temporary mounting (methylene blue) or by permanent stained (Haematoxylin-eosin).
7. Histology of male and female reproductive organs and accessory reproductive glands

Distribution of Marks**Marks**

1. Cytological preparation	15
2. Problems on genetics (any two)	20
3. Spermatogenesis/oogenesis/sperm vitality	10
4. Sperm count/vaginal smear/hypo-osmotic test for fertility	10
5. Identification and comment on spots (1-5)	10
6. Class record	10
7. Viva-voce	05

80**Internal Assessment**

20

Total marks-----
100

- **Suggested Readings**

Structure and function of Invertebrates

1. Hyman L.H. The Invertebrate Vol. I, Protozoa through Ctenophora. McGraw-Hill Co., New York.
2. Barrington E.J.W. Invertebrate structure and function. Thomas Nelson and sons Ltd., London
3. Jagerstein G. Evolution of Metazoan life cycle . Academic press, New York and London.
4. Hyman L.H. The invertebrate vol. 2 McGraw-Hill Co., New York.
5. Hyman L.H. The invertebrate vol. 8 McGraw-Hill Co., New York.
6. Barnes R.D. Invertebrate Zoology W.B. Saunders and Co., Philadelphia
7. Russet Hunter W.D.D. biology of higher invertebrate The Macmillan Co. Ltd., London.
8. Hyman L.H. The Invertebrates, smaller coelomate groups. Vol. 5 McGraw-Hill Co. New York.
9. Read C.P. Animal Parasitism. Prentice Hall. New-Jersey.
10. Kudo R.R. (1966) Protozoology, Charler, C. Thomas Springfield, Illinois.
11. Barradailes L.A. and potts F.A. Invertebrates (1961) The Eastham L.E. S. Saunders, Cambridge University Press, Cambridge.
12. Russel W.D. Hunter, Biology of lower invertebrates McMillan, New York.
13. Marshall A.J. and Williams W.D. (1972) J. B. Zoology of Invertebrates , EIBs and McMillan, London.
14. Gtryyrt V. and Graham A. A Functional anatomy of Invertebrates. Academic press, New York.
15. Backlemiccher W.N. Principles of comparative anatomy of Invertebrates Oliver and Boyed Edinberg.
16. Hadisi J. The Evolution of Metazoa. Pergamon Press, Oxford.
17. Dales R.P. Annelids, Hutchinson, London.
18. Green J. Biology of Crustacea, Wither by, London
19. Morton J. E. Mollusca, Hutchinson, London
20. Nichols D. Echinodermata, Hutchincon, London

General Physiology

1. Text Book of Physiology & Biochemistry : Bell, G.E. & Davidson, J.N. & Emslie D. Smith, 1922.
2. Medical Physiology : A Wiley Medical Publication, John Wiley & Sons, New York.
3. Mineral Metabolism : Comar, C.L. & Felix Bronner (1961) Acad Press, New York & London.
4. A Text Book of General Physiology : Dayson (1964) : Little Brown & Co. Boston.
5. Animal Physiology : R. Eckert & D. Randall (1983) 2nd Edn., W.H. Rexeman & Co.
6. Biochemistry & Physiology of the Cell : (2nd Edn.), M.A. Edwards & K.A. Hassall (1980) Mc. Graw Hill Co.
7. The Physiology of Cells : Cuthe F. (1968) : The Macmillan Co.
8. Textbook of Medical Physiology: Guyton, A.G. (1968). 7th Edn. Saunders Pub.
9. Samson Wrights Applied Physiology : Oxford University Press.
10. Comparative Animal Physiology C.L. Prosser, W.B. Saunders & Company.
11. Animal Physiology : Mechanism & Application, R. Eckert, W.H. Freeman & Company.
12. General & Comparative Animal Physiology : W.S. Hoar.
13. Medical Physiology : W.F. Ganong (1981) : 10th Edn. Lange Medical Publications.
14. Principles of Anatomy and Physiology: Tortora Grabowski, 9th Edn., John Willey & Sons.
15. Reproductive Physiology of Vertebrates: Van Tienhoven, A. (1983): 2nd Edn. Cornell Univ. Press, New York.

Cell Biology and Genetics

1. Cell and Molecular Biology by De Robertis- E. D. P., I. S. E. publication.
2. Molecular Biology by Turner P. C. and Mc Lennan , Viva Books Pvt. Ltd.
3. Advanced Molecular Biology by Twyman R. M., Viva Books Pvt. Ltd.
4. Molecular Biology by Freifelder D., narosa publication House.
5. Gene VI by Benjamin Lewis, Oxford press.
6. Gene VIII by Benjamin Lewis, Oxford press.
7. Molecular biology of Gene by Watson J. D. et. al., Benjamin publication.
8. Molecular cell Biology by Darnell J. Scientific American Books USA.
9. Molecular Biology of the Cell by Alberts B., Bray D. Lewis J., garland publishing Inc.
10. Genetics Vol. I and II by Pawar C. B., Himalaya publication.
12. Essentials of Molecular Biology by Freifelder D., narosa publication House.
13. Molecular Cell Biology by Laodish H., Berk A., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell J., W. H. Freeman and Co.
14. The Cell: Molecular Approach by Cooper G. M.
15. Molecular Biology by Upadhay A and Upadhay K. Himalaya publication.

Advance reproductive Biology

1. Developmental Biology. 2nd Edition. Leon W. Browwer Saunders College publishing.
2. Current Topics in Developmental Biology eds. R. A. Pedersen and G. P. Schatten.
3. Principles of animal developmental biology: S. C. Goel, Himalaya Publishing House.
4. Developmental Biology, S.F. Gilbert. 4th Edn. Sinauer Associates Inc. Publishers.
5. An Introduction to Developmental Biology: D. A. Ede.

6. Principles of developmental: Paul Weiss edited by Hafner publishing company New York.
7. Cells into organs. 2nd Edition. The forces that shape the Embryo. John Philip Trinkaus ed. Tom Aloisi.
8. Principles of development: Lewis Wolpert et al. 1998. Oxford University Press.
9. Foundations of Embryology. B. M. Patten & B. M. Carlson. Tata McGraw Hill Publishing Company Ltd., New Delhi.
10. An Introduction to Embryology: Balinsky (1981) 5th Ed. (CBS College Publishing).
11. Embryonic and foetal development. Cambridge University Press by Austin and Short, 1982, 1994 2nd Ed.
12. Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2. Lamming 1984, 2000.

Semester-II

Paper- V, Structure and Function of Vertebrates

Unit-I

- 1.1 Origin and ancestry of Chordata.
- 1.2 General organization and affinities of Cephalochordata.
- 1.3 General characters and affinities of Dipnoi.
- 1.4 Organs and mechanism of respiration in Pisces and Amphibia.

Unit-II

- 2.1 Vertebrate integument and its derivatives.
- 2.2 Appendicular skeleton (Limbs and girdles) in Amphibia, Reptilia, Aves and Mammals.
- 2.3 General body organization and classification in Chelonia.
- 2.4 Evolution of urinogenital organs in vertebrates.

Unit-III

- 3.1 Origin of Birds.
- 3.2 Cetacea: general characters and adaptations.
- 3.3 Comparative anatomy of the brain in vertebrates (teleost, frog, lizard, fowl and rat).
- 3.4 Autonomous nervous system in vertebrates: structure and functions.

Unit- IV

- 4.1 Structure, development and metamorphosis of Ammonoetous.
- 4.2 Evolution of heart in vertebrates.
- 4.3 Sense organs in vertebrates: lateral line system and electroreception in fishes.
- 4.4 Evolution of Man.

Semester-II

Paper-VI, Comparative Endocrinology

Unit-I

- 1.1 Hormones and functions in Coelenterata and Helminths.
- 1.2 Neurosecretory system in Annelida: structure, hormones and functions.
- 1.3 Neuroendocrine system in Mollusca: structure, hormones and functions.
- 1.4 Hormones and functions in Echinodermata.

Unit-II

- 2.1 Neuroendocrine system in crustacean; structure and hormones.
- 2.2 Endocrine control of metamorphosis, reproduction and colour change mechanisms in crustacea.
- 2.3 Cephalic neuroendocrine system in insects: structure and hormones.
- 2.4 Endocrine control of metamorphosis and reproduction in insects.

Unit-III

- 3.1 Pineal organ: structure, hormones and functions.
- 3.2 Hypothalamus: Nuclei, hormones and functions.
- 3.3 Pituitary: cell types, hormones and functions.
- 3.4 Hypothalamo-hypophysial system: neuroendocrine integration and feedback mechanisms in mammals.

Unit-IV

- 4.1 Thoracic endocrine glands: thyroid, parathyroid and ultimobranchial glands: structure, hormones and regulatory mechanisms.
- 4.2 Gastro-entero-pancreatic endocrine system: endocrine pancreas and gastro intestinal tract: endocrine cells, hormones and functions.
- 4.3 Adrenal gland: structure, hormones and functions in vertebrates.
- 4.4 Gonadal hormones in vertebrates and their hormonal actions, feedback mechanisms.

Semester-II

Paper-VII, Molecular Biology and Biotechnology

Unit-I

- 1.1 Genome organization – C value paradox, genome size, Cot curves, repetitive and non repetitive DNA sequences , Cot $\frac{1}{2}$ and Rot $\frac{1}{2}$ values, pseudo- genes, gene families, gene clusters, organelle genome, chromosomal structure , chromatin organization and remodeling, DNA structure, forms of DNA.
- 1.2 DNA replication – molecular mechanisms of prokaryotic and eukaryotic DNA replication, regulation of replication.
- 1.3 DNA damage and repair – types of DNA damages, excision repair system, mismatch repair, recombination repair, double strand break repair, and transcription coupled repair.
- 1.4 Recombination- homologous and non homologous recombination.

Unit-II

- 2.1 Transcription- prokaryotic and eukaryotic transcription, RNA polymerases, transcriptional unit, initiation, elongation, termination, transcriptional factors.
- 2.2 Regulation of transcription – Operon, positive and negative control, attenuation phage strategies, anti-termination, response elements and inducible elements.
- 2.3 Translation - prokaryotic and eukaryotic translation, genetic code, altered code in elongation, termination factors, fidelity of translation, post translational modifications.
- 2.4 Mobile DNA elements – transposable elements, IS elements, P elements, retroviruses, retrotansposons.

Unit-III

- 3.1 Antisense and ribozyme technology – initiation of splicing, polyadenylation, molecular mechanisms of antisense molecules, miRNA , siRNA, gene silencing.
- 3.2 Isolation and sequencing of DNA, gene amplification, PCR, RAPD, RFLP, Maxam-Gilbert, Sanger's dideoxy methods.
- 3.3 Splicing and Cloning – Cloning vectors for recombinant DNA technology-

- plasmids, cosmids, phagemids, YACS, gene replacement, restriction enzymes.
- 3.4 Hybridization techniques – Southern- Northern hybridization, microarray.

Unit-IV

- 4.1 Medical biotechnology-Application of restriction fragment length polymorphism (RFLP) in forensic science, disease prognosis and genetic counseling.
- 4.2 Agricultural biotechnology– biofertilizers, bioinsecticides, biogas
- 4.3 Immunobiotechnology-Hybridoma technology and monoclonal antibodies.
- 4.4 Industrial and Environmental biotechnology-microbial production of fermentation products, enzymes, antibiotics, single Cell proteins and biosensors.

Semester-II

Paper-VIII, Advance Developmental Biology

Unit-I

- 1.1 Implantation in Mammals.
- 1.2 Foetal membranes- types, structure and functions.
- 1.3 Placenta-types, structure, functions. Hormones of placenta and their functions.
- 1.4 Metamorphosis in Amphibia: morphogenetic and biochemical mechanism, hormonal control.

Unit-II

- 2.1 Regeneration in vertebrates: tail, limb, lens and retina.
- 2.2 Apoptosis- mechanism and significance.
- 2.3 Ageing- mechanism, concepts and models.
- 2.4 Polymorphism (caste differentiation) in insect (Termites, Honey bees and Ants).

Unit-III

- 3.1 Multiple ovulation and embryo transfer technology (MOET).
- 3.2 Application of embryonic stem cells, clinical and economic significance.
- 3.3 Embryonic sexing, cloning, screening for genetic disorder diagnosis (ICSI, GIFT etc.)
- 3.4 Cloning of animals by nuclear transfer.

Unit-IV

- 4.1 Immunocontraception- fertilization, inhibition and pregnancy termination.
- 4.2 Classical contraceptive techniques: Physical, chemical, surgical and IUCD devices.
- 4.3 Anti-androgen and anti-spermiogenic compounds (LDH-CY and SP-10)
- 4.4 Role of mutants and transgenics in human welfare.

Semester-II, Practical-III, Structure and Function of Vertebrates and Comparative Endocrinology

Section-A

1. Study of museum specimens.

Classification of vertebrates up to order and comments on the specimens representing all phyla.

2. Dissection (Any animal)

- a) Brain and cranial nerves- cultured Fishes/Rat.
- b) Arterial and venous systems- cultured Fishes/Rat
- c) Urinogenital system- cultured Fishes/Rat.
- d) Reproductive systems in cultured fishes/Rat.

- e) Internal ear in fish, Weberian ossicles in fish, accessory respiratory organs in cultured fish.
- 3. **Mounting**
 - a) Fish – scales, ampullae of Lorenzini, otolith, striated muscles, cartilage.
- 4. **Microtomy, Histology and Skeleton**
 - a) Fixation, embedding, sectioning and staining of the internal organs of vertebrates.
 - b) Study of slides of internal organs of vertebrates.
 - c) Axial and appendicular skeleton of fowl and rabbit.

Note: Students should prepare at least 10 permanent stained micropreparations.

Section-B

Microtomy - Fixation, embedding, sectioning and staining of the endocrine gland.

- 3. **Histological study** –
 - a) Histological slide of endocrine glands and gonadal endocrine components, EM structure of endocrine gland.
 - b) Identification of pituitary cell type.
 - c) Identification of α , β , γ , cells of Islets of Langerhans.
- 4. **Dissections**
 - a) Dissection of endocrine gland in cockroach
 - b) Dissection of endocrine gland- pituitary, thyroid parathyroid, adrenal in cultured fish/rat.

Distribution of Marks	Marks
Dissection of breed fish/rat	15
Stained permanent preparation:	05
Identification and comment on the spots (1-10)	20
Submission of stained permanent slides	05
Dissection of Endocrine glands	10
Histological staining of endocrine gland	10
Class Record	10
Viva-voce	05

	80
Internal Assessment	20

Total marks	100

Practical –IV, Molecular Biology, Biotechnology and Developmental Biology

Section-A

- 1. Demonstration of glycogen / carbohydrate – PAS reaction.
- 2. Demonstration of DNA: Feulgen’s reaction.
- 3. Demonstration of DNA: RNA: Methyl Green- Pyronin reaction.
- 4. Demonstration of Lipid: Sudan Black B staining.
- 5. Demonstration of Protein: HgBP staining.

5. Histochemical analysis of alkaline phosphatase
6. Histochemical analysis of acid phosphatase
7. Biochemical estimation of sugar: O-toluidine method.
8. Biochemical estimation of protein: Lowrey's method.
9. Biochemical estimation of DNA: Diphenylamine method.
10. Biochemical estimation of RNA: Orcinol method.
11. To perform tests for qualitative analysis of saliva
12. To perform tests for qualitative analysis of bile
13. Separation of amino acids by paper chromatography and TLC.

Section-B

1. Study of the reproductive system in mammals.
2. Study of different types of eggs on the basis of their yolk content.
3. Collection and development stages of live eggs of Lymnea or any gastropod.
4. Collection of developmental stages of insects/fishes.
5. Study of developmental stages of frog through slides and whole mounts.
6. Chick embryo mounting by window method.
7. Study of developmental stages of chick through slides and whole mounts.
8. Morphological study of different types of placenta.
9. Histological study of placenta.
10. Sperm count from any domestic animal.

Distribution of Marks

Marks

1. Histochemical demonstration of DNA/RNA protein / carbohydrate/lipids/enzymes	15
2. Estimation of sugar/protein/DNA/RNA/ qualitative analysis of saliva/bile	15
3. Whole mount preparation of chick embryo/sperm count.	10
4. Preparation of development stages of live eggs of Lymnea	10
5. Identification and comment on spots (1-5)	15
6. Class record	10
7. Viva voce	05

80

Internal Assessment

20

Total marks

100

• Suggested Readings

Structure and function of Vertebrates

1. Alexander R.N., The Chordata, Cambridge University Press London.
2. Barrington EJW, The Biology of Hemichordates and Protochordates, Oliver and Boid Edinberg.
3. Bourne G.H., The structure and function of nervous tissue Academic press New York.

4. Kingslay J.S, Out lines of Comparative anatomy of vertebrates, Central Book Depot, Allahabad.
5. Honyelli A.R. The Chordates Cambridge University Press, London
6. Smith H.S. Evolution of Chordate structure, Hold Rinehart and Winton Inc. New York
7. Walter H.A. and Sayles L.D. Biology of Vertebrates Macmillan and co. New York
8. Romer A.S. Vertebrate body W.P. Sanders co., Philadelphia.
9. Young J.Z. Life of Vertebrates Oxford University Press, London.
10. Young J.Z. Life of Mammals Oxford University Press, London.
11. Colbert E.H. Evolution of Vertebrates John Wiley and sons Inc. New York.
12. Kent C.J. Comparative anatomy of Vertebrates.
13. Waterman A.J. Chordate Structure and Functions Macmillan Co. New York.
14. Montagna W. Comparative anatomy clarendon press, Oxford
15. Weichert C.K. Preach W. Elements of Chordates anatomy McGraw-Hill book co., New York.
16. Lovettrup S. The phytogeny of Vertebrates John Wiley and sons Inc., London.
17. Joysey K.A. and Kemp T.S. Vertebrate Evolution Oliver and Boyd, Edinberg.
18. Romer A.S. Vertebrate Paleontology University of Chicago Press, Chicago.
19. Newman Phylum Chordata.
20. Goodrich E.S. Structure and development of vertebrates. Dover publications Inc., New York
21. Hard disty M.W. and Potter I.C. Biology of Lampreys Academic Press Newyork
22. T.B.of Zoology Parker and Haswell W.A. Mac millon co. Ltd. London
23. The Biology of Amphibia Noble G.K. Dover Publication Inc Newyork

Comparative Endocrinology

1. General & Comparative Endocrinology : E.J.W., Barrington, Oxford, Clarendon Press.
2. Text Book of Endocrinology : R.H. Williams, W.B. Saunders.
3. Endocrine Physiology : C.R. Martin, Oxford University Press.
4. Comparative Endocrinology : A Gorbman et al, John Wiley & Sons.
5. Medical Physiology : W.F. Ganong (1981) : 10th Edn. Lange Medical Publications.
6. Principles of Anatomy and Physiology: Tortora Grabowski, 9th Edn., John Willey & Sons.
7. Reproductive Physiology of Vertebrates: Van Tienhoven, A. (1983): 2nd Edn. Cornell Univ. Press, New York.
8. The Pituitary Gland : Imura, H. (1994), 2nd Edn., Comprehensive Endocrinology Revised Series Raven, New York.
9. Comparative Vertebrate Endocrinology : Bentley, P.J. (1976) Cambridge University Press, Cambridge.
10. General & Comparative Endocrinology : E.J.W., Barrington, Oxford, Clarendon Press.
11. Text Book of Endocrinology : R.H. Williams, W.B. Saunders.
12. Comparative Vertebrate Endocrinomental : Bentely, P.J. (1976) Cambridge University Press, Cambridge.
13. Invertebrate endocrinology: D. B. Tembhare, Himalaya publishing House (2012)

Molecular Biology and Biotechnology

1. Harper's Review of Biochemistry, Prentice Hall.
2. Principles of Biochemistry by Lehninger and Nelson, CBS publications and Distributors.
3. The Biochemistry "Students companion" by Allen J. Scism, Prentice Hall.
4. Fundamentals of Biochemistry by Jain J. L., S. Chand Publication.
5. Principles of Biochemistry by Zubay J. L., WM. C. Brown Publishers.
6. Principles of Biochemistry by Horton, Prentice Hall.
7. Concept of Biochemistry by Boyer R., Coel publication co.
8. Harper's Biochemistry eds. Murray, R. K. P. and Granner, D. K. Prentice Hall.
9. Biochemistry by Mathews C. K. and Van Holde K. E., Benjamin C. publishing Co.
10. Biochemistry by Garrett R. H. and Grisham C. M., Saunders College publication.
11. Cell and Molecular Biology by De Robertis- E. D. P., I. S. E. publication.
12. Molecular Biology by Turner P. C. and Mc Lennan , Viva Books Pvt. Ltd.
13. Advanced Molecular Biology by Twyman R. M., Viva Books Pvt. Ltd.
14. Molecular Biology by Freifelder D., narosa publication House.
15. Gene VI by Benjamin Lewis, Oxford press.
16. Gene VIII by Benjamin Lewis, Oxford press.
17. Molecular biology of Gene by Watson J. D. et. al., Benjamin publication.
18. Molecular cell Biology by Darnell J. Scientific American Books USA.
19. Molecular Biology of the Cell by Alberts B., Bray D. Lewis J., garland publishing Inc.
20. Genetics Vol. I and II by Pawar C. B., Himalaya publication.
21. Essentials of Molecular Biology by Freifelder D., narosa publication House.
22. Molecular Cell Biology by Laodish H., Berk A., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell J., W. H. Freeman and Co.
23. The Cell: Molecular Approach by Cooper G. M.
24. Molecular Biology by Upadhay A and Upadhay K. Himalaya publication.

Gamete and Developmental Biology

1. Developmental Biology. 2nd Edition. Leon W. Browwer Saunders College publishing.
2. Current Topics in Developmental Biology eds. R. A. Pedersen and G. P. Schatten.
3. Principles of animal developmental biology: S. C. Goel, Himalaya Publishing House.
4. Developmental Biology, S.F. Gilbert. 4th Edn. Sinauer Associates Inc. Publishers.
5. An Introduction to Developmental Biology: D. A. Ede.
6. Principles of developmental: Paul Weiss edited by Hafner publishing company New York.
7. Cells into organs. 2nd Edition. The forces that shape the Embryo. John Philip Trinkaus ed. Tom Aloisi.
8. Principles of development: Lewis Wolpert et al. 1998. Oxford University Press.
9. Foundations of Embryology. B. M. Patten & B. M. Carlson. Tata McGraw Hill Publishing Company Ltd., New Delhi.
10. An Introduction to Embryology: Balinsky (1981) 5th Ed. (CBS College Publishing).
11. Embryonic and foetal development. Cambridge University Press by Austin and Short, 1982, 1994 2nd Ed.
12. Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 &2. Lamming 1984, 2000.

Semester- III

Paper-IX, Parasitology

Unit-I

- 1.1 Spirochaetes and Rickettsia- Life cycle, mode of transmission, infection and treatment.
- 1.2 *Vibrio cholerae*- Life cycle, mode of transmission, infection and treatment.
- 1.3 *Clostridium titani*- Life cycle, mode of transmission, infection and treatment.
- 1.4 *Yersinia pestis* (Plague bacteria) - Life cycle, mode of transmission, infection and treatment.

Unit-II

- 2.1 Influenza and H₁ N₁ viruses - Life cycle, mode of transmission, infection and treatment.
- 2.2 Polio virus - Life cycle, mode of transmission, infection and treatment.
- 2.3 Dengue and Hepatitis - Life cycle, mode of transmission, infection and treatment.
- 2.4 Rabies virus- Life cycle, mode of transmission, infection and treatment.

Unit-III

- 3.1 *Entamoeba* - Life cycle, mode of transmission, infection and treatment.
- 3.2 *Trypanosoma*- Life cycle, mode of transmission, infection and treatment.
- 3.3 *Leishmania*- Life cycle, mode of transmission, infection and treatment.
- 3.4 *Giardia* and *Tricomonas* - Life cycle, mode of transmission, infection and treatment.

Unit-IV

- 4.1 *Wuchereria* and *Trichinella* - Life cycle, mode of transmission, infection and treatment
- 4.2 Malaria: pathogen vectors and mode of transmission, infection and treatment
- 4.3 Epidemic typhus: - pathogen vectors and mode of transmission, infection and treatment.
- 4.4 Toxins and antitoxin.

Semester –III

Paper-X, Immunology

Unit-I

- 1.1 Immune system - innate and adaptive immunity.
- 1.2 Cells and organs of immune system – hematopoiesis, primary and secondary lymphoid organs.
- 1.3 Antigens and antibodies – antigenicity, immunogenicity, antigen – antibody interactions, superantigens, antibody diversity.
- 1.4 Organization of immunoglobulin genes – antibody structure, heavy, light, kappa, lambda chain gene rearrangements.

Unit-II

- 2.1 Complement system – classical, alternative and lectin pathways, regulation of complement system, biological consequences of complement activation.
- 2.2 Major Histocompatibility Complex (MHC) - general organization and inheritance of the MHC, MHC molecules and genes, cellular distribution and regulation of MHC expression.
- 2.3 T cells - maturation, activation and differentiation, T cell receptors.
- 2.4 B cells - maturation, activation and differentiation, B cell receptors.

Unit-III

- 3.1 Cytokines - properties of cytokines, cytokine receptors, cytokine secretion by T_H1 and T_H2 subsets, cytokine-related diseases, therapeutic uses of cytokines and their receptors.
- 3.2 Cell mediated cytotoxic responses – effector mechanisms, leukocyte activation and migration.
- 3.3 Hypersensitivity reactions – types, prevalence, factors, mechanisms of type I to IV hypersensitivity reactions.
- 3.4 Immune tolerance and autoimmunity – central, peripheral and acquired tolerance, organ specific autoimmune diseases, animal models, treatment of autoimmune diseases.

Unit-IV

- 4.1 Transplantation immunology – blood antigens, transplantation rejection, graft rejection, familial grafting, tissue typing, cross matching, immunosuppression.
- 4.2 Tumor immunology – types and roles of tumor antigens, immune response to tumor, tumor evasion of immune system, cancer immunotherapy.
- 4.3 Immune response to infectious diseases and immune defeciences – bacterial, fungal, viral, parasitic diseases and AIDS.
- 4.4 Applications of immunology and immunotechniques – immunotherapies, immunization and vaccine production, precipitation reaction, agglutination reaction, radioimmunoassay, ELISA.

Semester-III, Practical-V, Parasitology and Immunology

Section-A

1. Study of different types of parasitic protozoans from permanent slide/chart
2. Study of different types of parasitic helminthes from permanent slide/chart
3. Study of different types of insect vectors.
4. Collection and identification of various ecto and endo parasites.
5. Study of mouth parts of insect vectors.
6. Study of life cycles of various parasites.

Section-B

7. Antigen-antibody reaction.
8. Preparation of tissue sections of thymus, spleen, and lymph nodes.
9. Immunological diagnosis of pregnancy.
10. Agar gel diffusion.
11. Demonstration of immunoelectrophoresis.
12. Identification of T and B cells.
13. Demonstration of Mast cells.

Distribution of marks

	Marks
1. Identification and comments on spot (1 to 10)	20
2. Demonstration of Gram +ive (Positive), Gram – ive (Negative) bacteria.	10
3. Antigen-antibody reaction/Agar gel diffusion/diagnosis of pregnancy	10
4. T and B cells identification/Mast cell demonstration	15
5. Submission of slides and collection	10
6. Practical record	10
7. Viva-voce	05

80

Internal Assessment

20

Total marks

100

- **Suggested Readings**

Parasitology

1. Brock Biology of Microorganisms (Ed. IX) M. T. Madigan J. M. Martinko and J. Parker. Prentice Hall International Publication.
2. The Nematode Parasite in Vertebrate, W. Youle and Maplestone.
3. General Parasitology, V. A. Dogiel.
4. Helminthology, E. C. Faury.
5. Platyhelminthes and Parasitism, D.R. Birt.
6. Animal Parasite- O.W. Aisen
7. Parasitic Protozoa, J.P. Kreier and J.R. Baker. Allen and Unwin Press.
8. Medical and Veterinary Protozoology M. G. Kathering , A. James Paul and V. Zaman. Churchill Livingstone.

Immunology

1. Immunology – R. C. Kubly et al.
2. Immunology - Tizzard.
3. Immunology -. Roitt, Brostoff and D. Male.
4. Microbiology- M. T. Pelzer. Jr. E. C. S. Chan and N. R. Krieg. Tata McGraw -Hill
5. Immunology - Abbas

Semester-III**Paper-XI, Special Group-Entomology-I****Insect Morphology and Physiology****Unit-I**

- 1.1 Integument: molecular structure, moulting and sclerotization.
- 1.2 Morphology of head, thorax and abdomen.
- 1.3 Appendages: antennae, legs and genitalia.
- 1.4 Wing structure and mechanism of flight.

Unit-II

- 2.1 Mouth parts: type, morphology and feeding mechanism.
- 2.2 Structure of alimentary canal and salivary glands, mechanism of digestion.
- 2.3 Respiratory system: tracheal, aquatic and plastron respiratory mechanism.
- 2.4 Circulatory system: organs, mechanism of circulation, haemolymph- cellular and chemical composition. Functions of haemocytes.

Unit-III

- 3.1 Excretory system: organs and physiology of excretion.
- 3.2 Nervous system: structure and anatomy of brain and ventral nerve cord.
- 3.3 Neuroendocrine system: structure and function, role in metamorphosis and reproduction.
- 3.4 Exocrine glands: Pheromones and allomones-chemistry and functions.

Unit-IV

- 4.1 Reproduction: male and female reproductive system, structure of testis and ovary, mechanism of spermatogenesis and vitellogenesis.
- 4.2 Specialized reproductive mechanism: viviparity, polyembryony, paedogenesis and parthenogenesis.
- 4.3 Early embryonic development up to germ band formation.
- 4.4 Metamorphosis: types of larvae and pupae.

Semester-III, (M. Sc. Part-II)
Paper-XII, Special Group-Entomology-II
Classification and Industrial Insects

Unit-I

- 1.1 Modern scheme of insect classification and general characters of various Orders.
- 1.2 General characters and classification of Thysanura and Collembola.
- 1.3 General characters and classification of Mallophaga and Siphunculata.
- 1.4 General characters and classification of Siphonaptera.

Unit-II

- 2.1 General characters and classification of Orthoptera.
- 2.2 General characters and classification of Hemiptera.
- 2.3 General characters and classification of Lepidoptera.
- 2.4 General characters and classification of Coleoptera.

Unit-III

- 3.1 Mulberry silkworm *Bombyx mori*, life cycle, silk gland and silk proteins.
- 3.2 Silkworm rearing, cocoon harvesting and seed production.
- 3.3 Bacterial and viral diseases in silkworm.
- 3.4 Lac insect-biology, lac cultivation and economic importance.

Unit-IV

- 4.1 Tasar sericulture- life cycle, host plant, rearing, cocoon formation and silk production.
- 4.2 Eri sericulture- life cycle, host plant rearing and silk production.
- 4.3 Honey bee- types, life cycle, colony formation and apiary products.
- 4.4 Bee keeping- movable frame hive, bee rearing management and diseases.

Semester-III, Practical-VI, Special Group-Entomology

1. Dissection of various organs and systems in available insects such as cockroach, grasshopper, cricket, molecricket, red cotton bug, honey bee, beetle, house fly, butterfly/moth and caterpillars.
2. Permanent stained micro preparations- alimentary canal, salivary glands, gastric caecae, Malpighian tubules, testis, ovary, sex accessory glands, exocrine glands, endocrine glands, brain and other ganglia.
3. Whole mount preparations of mouth parts, appendages, proventricular teeth, antennae and legs.
4. Insect collection- preservation, identification, classification and characters up to families belonging to orders- Odonata, Orthoptera, Dictyoptera, Hemiptera, Lepidoptera, Coleoptera, Hymenoptera, Diptera etc.
5. **Physiological Experiments:**
 - a) Differential and total haemocytocytes count.
 - b) Qualitative survey of digestive enzymes in salivary glands.
 - c) Qualitative survey of digestive enzymes in gut.
 - d) Estimation of total proteins/carbohydrates/lipids in haemolymph/tissues.
 - e) Detection of uric acid as end product of excretion in terrestrial insects.
 - f) Chromatographic separation of free amino acids in haemolymph.
 - g) Separation of haemolymph proteins by electrophoresis and specific protein by blotting.
 - h) Estimation of Na⁺ and K⁺ in haemolymph by flame photometer.

- i) Estimation of DNA and RNA in haemocytes/tissues.
6. Visits to agricultural fields, national parks and forests for collection and observations of insects are compulsory.

Note: Student should submit insect collection and about 10 morphological and 10 histological slide preparations at the time of examination.

Distribution of Marks	Marks
1. Dissection	15
2. Physiological Experiment	10
3. Identification of histological slides and insects (1-15)	30
4. Permanent stained preparation	05
5. Class records and insect collection	10
6. Submission of histological slides	05
7. Viva-voce	05

	80
Internal Assessment	20

Total marks	100

Semester –III

Paper-XI, Special Group-Fish and Fisheries -I

General studies

Unit-I

- 1.1 Origin and Evolution of fishes: Fossil record, classification, cyclostoms, ostracoderms, placoderms, Sharklike fisher, Bony fishes
- 1.2 Development of jaws and limbs in fishes.
- 1.3 Classification and general characters of Placoderms: Acanthodii, Coccostei, Pterychthyes, Stegoselachii, Palaeospondyli.
- 1.4 Affinities of Placoderms and fossil record.

Unit-II

- 2.1 Classification and general characters of Elasmobranch/Chondrichthyes: Sharks and Rays, Holocephali
- 2.2 Affinities of Elasmobranchs, specialized characters of Elasmobranchs.
- 2.3 Classification and general characters of Actinopterygii/Ray finned fishes: Palaeonisciformes, Polypteriformes, Acipenseriformes, Amiiiformes, Teleostea (Osteoglossomorpha, Elopomorpha, Clupeomorpha, Euteleostei)
- 2.4 Affinities of Actinopterygians.

Unit-III

- 3.1 Dipnoi: General characters, classification, origin, fossil Dipnoians and distribution of Dipnoians.
- 3.2 Specialized characters of Dipnoi, Blood vascular system of Protopterus and affinities of Dipnoians.
- 3.3 Respiratory system: Structure of gills in fishes, gill histology
- 3.4 Blood supply and mode of respiration and gaseous exchange in teleosts.

Unit-IV

- 4.1 Accessory respiratory organs: Origin of air breathing organs; skin, buccopharynx opercular cavity, air bladder
- 4.2 Mechanism of air breathing, function of accessory respiratory organ.
- 4.3 Air bladder: Origin, Development, types of air bladder; physostomous, physoclists, structure of gas secreting complex
- 4.4 Blood supply to air bladder and functions of air bladder

Semester-III

Paper-XII, Special Group-Fish and Fisheries -II

Applied fisheries

Unit-I

- 1.1 Fresh water fisheries of India, Riverine and Reservoir fisheries.
- 1.2 Estuarine and Marine fisheries of India.
- 1.3 Breeding of Indian Major carps: i Natural breeding, ii Induced breeding, iii Methods of obtaining eggs, spawn, fry and fingerlings from natural resources.
- 1.4 Neuroendocrine control of carp reproduction.

Unit-II

- 2.1 Culture of exotic fishes – common carp, Composite culture.
- 2.2 Monoculture, Monosex culture.
- 2.3 Integrated Fish farming – Poultry, Duck, Fish rice culture.
- 2.4 Sewage fed fisheries

Unit-III

- 3.1 Catfish culture
- 3.2 Trout culture
- 3.3 Ornamental fish culture: i) Oviparous, ii) Live bearers.
- 3.4 Culture of sea weeds and Spirulina.

Unit-IV

- 4.1 Pearl culture
- 4.2 Oyster culture: i) Species- edible ii) Culture methods.
- 4.3 Prawn culture (Life cycle and breeding)
- 4.4 Frog culture

Semester-III, Practical-V, Special Group-Fish and Fisheries

1. Identification of local fishes upon species.
2. Internal anatomy of fish in general, reproduction and urino genital system, Endocrine glands.
3. Cranial nerves in *Wallago* and *Labeo*.
4. Identification of various stages of fry & fingerlings of major carps.
5. Permanent preparation of various scales.
6. Estimation of dissolve oxygen in water sample.
7. Estimation of CO₂ in water sample.
8. Estimation of chloride sample in water.
9. Estimation of protein in blood serum of fish.
10. Estimation of sodium in blood of fish.
11. Estimation of potassium in blood of fish.

Distribution of Marks:	Marks
1. Major Dissection	15
2. Physiology Experiment	15
3. Mounting of Scale	05
4. Identification of fishes	30
5. Practical Record	10
6. Viva voce	05

	80
Internal Assessment	20

Total marks	100

Semester –III

Paper-XI, Special Group-Mammalian Reproductive Physiology (MRP)-I

Reproductive Process in Male

Unit-I

- 1.1 Development, descent and structure of the testis.
- 1.2 Spermatogenesis: Molecular changes, hormonal regulation, and spermiogenesis.
- 1.3 Sertoli cells: Structure , functions, blood testis barrier.
- 1.4 Leydig cells: Structure , functions and interaction with peritubular and Sertoli cells.

Unit-II

- 2.1 Epididymis : Structure and function.
- 2.2 Structure of spermatozoa and anomalies.
- 2.3 Sperm capacitation : molecular and biochemical changes, decapacitation.
- 2.4 Vas deferens: Structure and function.

Unit-III

- 3.1 Seminal Vesicle: Structure, function and regulation.
- 3.2 Prostate gland: Structure, function and prostatic cancer.
- 3.3 Cowpers gland: Structure, function and anomalies.
- 3.4 Penis: Structure and mechanism of erection.

Unit-IV

- 4.1 Male reproductive behaviour: Mating system, neural and hormonal control.
- 4.2 Pheromones : types, structure and function.
- 4.3 Infertility: causes and remedy.
- 4.4 Andrologically relevant diseases in advanced age.

Semester-III

Paper-XII, Special Group-Mammalian Reproductive Physiology-II

Reproductive Process in Female

Unit- I

- 1.1 Differentiation of the ovary and female genital tract.
- 1.2 The process of folliculogenesis and its hormonal control.
- 1.3 Recruitment, selection, dominance of follicle and signaling for ovulation.
- 1.4 Follicle wall: Theca, differentiation, steroid hormone synthesis (2-gonadotropin, 2-cell concept).

Unit-II

- 2.1 Estrous cycle in mammals.
- 2.2 Menstrual cycle and Menopause.
- 2.3 Mechanism and hormonal control of ovulation .
- 2.4 Corpus luteum : histogenesis, function, maintenance and luteolysis.

Unit-III

- 3.1 Oviduct: structure, regional differentiation and function.
- 3.2 Uterus: Types, abnormalities.
- 3.3 Cervix-structure, functions.
- 3.4 Vagina-structure, function, detection of various stages of oestrous cycle by vaginal cytology, vaginal plug.

Unit-IV

- 4.1 Onset of puberty and delayed puberty.
- 4.2 Prostaglandins and their role in reproduction .
- 4.3 Anatomy and growth of mammary glands.
- 4.4 Lactogenesis and galactopoiesis.

Semester-III, Practical-VI, Special Group-Mammalian Reproductive Physiology (MRP)

1. Surgical operation in rat / mice
Orchidectomy or Vasectomy or Epididymectomy
2. Dissection of male reproductive system of rat or mice and its description.
3. Sperm count for the assessment of fertility.
4. Study of spermatogenesis and identification of its various stages.
5. Estimation of fructose / sialic acid in reproductive tissue.
6. Experimental studies : (histological slides for identification)
 - a. Effects of castration and androgen replacement on sex accessory glands.
 - b. Effects of anti-androgen on testis and sex-accessory glands.
 - c. Effect of anti-cancer drugs on testis and sex-accessory glands, different duration and different regimen studies.
 - d. Effect of heavy metals on testis and sex accessory glands.

7. Histology : Histological changes in male reproductive organs and sex accessories during active and inactive stage.
8. Endocrine glands :
 - a. Pituitary gland : anatomy, cell types and identification of cell types.
 - b. Thyroid gland : Histology of active and inactive glands, effects of antithyroid drugs.
 - c. Adrenal : Normal histology and effects of metapyrone and corticosteroids administration.
9. Field Work : Visit to Artificial insemination centre.

Distribution of marks	Marks
1. Surgical operation	15
2. Dissection	10
3. Minor experimental analysis	10
4. Biochemical estimation	15
5. Identification and comments on spots (1-5)	15
6. Practical record	10
7. Viva-voce	05

	80
Internal Assessment	20

Total marks	100

Semester –III

Paper-XI, Special Group-Animal Physiology-I

Physiology of Digestion and Excretion

Unit-I

- 1.1 Histology of salivary glands, Mechanism of salivary secretion, composition and functions of saliva.
- 1.2 Histology of stomach, mechanism of secretion of gastric juice, composition and functions of gastric juice.
- 1.3 Histology of pancreas, mechanism of pancreatic secretion, composition and functions of pancreatic juice.
- 1.4 Histology of liver, bile secretion, its composition and functions.

Unit-II

- 2.1 Histology of small and large intestine, intestinal glands, its secretion and control, intestinal bacteria.
- 2.2 Neural and endocrine regulation of gastro intestinal movements and secretions.
- 2.3 Gastrointestinal hormones - Synthesis, chemical structure and functions.
- 2.4 Digestion and absorption of proteins, carbohydrates and fats in the gastrointestinal tract.

Unit-III

- 3.1 Functional anatomy of kidney.
- 3.2 Mechanism of formation of urine.
- 3.3 Normal and abnormal constituents of urine.
- 3.4 Mechanism of concentration and dilution of urine – The Counter current system.

Unit-IV

- 4.1 Regulation of urine and body fluid concentration and volume, hormonal mechanism of Antidiuratic hormone, Aldosterone and Renin – Angiotensin system in renal physiology.
- 4.2 Regulation of water, electrolytes and acid base, renal clearance.
- 4.3 Physiology of nitrogen excretion
- 4.4 Renal failure.

Semester –III

Paper-XII, Special Group- Animal Physiology-II

Physiology of Circulation

Unit-I

- 1.1 Types of heart (Myogenic and Neurogenic).
- 1.2 Anatomy, histology and nerve innervation of the heart, heart valves.
- 1.3 Pace maker and specialized conducting fibers.
- 1.4 Blood pressure and factors affecting blood pressure.

Unit-II

- 2.1 Cardiac cycle, Electrocardiogram (ECG).
- 2.2 Cardiac output, heart sound.
- 2.3 Haemodynamics.
- 2.4 Cardiac Failure.

Unit-III

- 3.1 Cellular composition and functions of blood.
- 3.2 Blood groups and Blood transfusion.
- 3.3 Blood sugars – Causes and control of hypoglycemia and hyperglycemia
- 3.4 Blood lipids- Causes and control of hypolipidimia and hyperlipidimia

Unit-IV

- 4.1 Plasma proteins- Albumins, globulins.
- 4.2 Haemostasis, Cascade of biochemical reactions involved in coagulation of blood.
- 4.3 Transport of O₂ & CO₂ by blood.
- 4.4 Lymph – composition, formation and functions.

Semester-III Practical-VI, Special Group- Animal Physiology

1. Physiology Experiments

- 1) Effect of pH, temperature and incubation on human salivary amylase activity.
- 2) Determination of a) clotting time, bleeding time.
 - b) Erythrocyte sedimentation rate and
 - c) Haemoglobin concentration.
- 3) Determination of protein, glucose in Urine.
- 4) Study of structure of RBCs in vertebrates.
- 5) Determination of protein, glucose in Urine from diabetic patient.

6) Total leukocyte count and differential leukocyte count.

2. Quantitative Analysis

- 1) Estimation of blood Glucose
- 2) Estimation of blood proteins
- 3) Estimation of blood triglycerides
- 4) Estimation of blood cholesterol
- 5) Estimation of blood Sodium, potassium, Calcium.
- 6) Estimation of blood alkaline & acid phosphates.
- 7) Blood amino-acid separation by TLC / Paper chromatography.

3. Qualitative Analysis

- 1) Normal & abnormal constituents of human urine.
- 2) Blood group detection by antisera.
- 3) Preparation and study of Urine crystals.
- 4) Estimation of serum urea.
- 5) Preparation and study of haemin crystals.

4. Histological Study

Stomach, Liver, Small intestine, Large intestine, Pancreas, Kidney, Thyroid, Pituitary, Blood smear, Heart, T.S. Vein, T.S. Artery.

Distribution of Marks:

	Marks
1. Physiology Experiment	15
2. Major quantitative analysis	15
3. Minor quantitative analysis	10
4. Qualitative analysis	10
5. Identification and comment on spots(1-5)	15
6. Practical Record	10
7. Viva-voce	05

Internal Assessment

Total marks

100

Semester-III

Paper-XI, Special Group-Cell Biology -I

Unit-I

- 1.1 Light Microscopy: principles, working and applications of Phase contrast, Interference, Fluorescence and Confocal microscopy. Electron Microscopy - Principles, working, applications of Scanning & transmission electron microscopy.
- 1.2 Basic principles of sedimentation , types of centrifuges, Preparative centrifugation, analytical centrifugation and applications of ultracentrifugation in cell fractionation. Cell separation by flow cytometry.
- 1.3 Isolation and purification of DNA, RNA & proteins. Isolation and purification, molecular weight determination & characterization of proteins.
- 1.4 NMR, ESR & X-Ray crystallography. Nanorobot & Nubot.

Unit-II

- 2.1 Principle, working and application of UV/Visible absorption spectroscopy, UV/Visible fluorescence spectroscopy, Mass spectroscopy.
- 2.2 Principle, working and applications of paper and thin layer chromatography, affinity chromatography, gel filtration chromatography, ion-exchange chromatography and Gas-liquid chromatography.
- 2.3 Cell culture techniques- Monolayer and polylayer. Design and functioning of tissue culture laboratory.
- 2.4 Culture media preparation and cell harvesting methods, Cell proliferation measurements, Cell viability testing, Tissue engineering.

Unit-III

- 3.1 Physicochemical properties of Nucleic acids. Enzymology of recombinant DNA technology- DNA modifying enzymes, restriction endonucleases, DNA ligases.
- 3.2 Cloning vectors – Plasmid, Lambda & M13 virus based vectors, phagemids, cosmids, YAC and BAC vectors.
- 3.3 Gene probes – Designing and production of gene probes for recombinant DNA technology.
- 3.4 Gene library – Construction of C-DNA & genomic library.

Unit-IV

- 4.1 Gene transformation and transfection methods for recombinant DNA. Genetic screening methods for gene constructs.
- 4.2 Applications of gene cloning – Sequencing cloned DNA, *invitro* mutagenesis, PCR based mutagenesis.
- 4.3 Applications of gene cloning – Expression of foreign genes, production of fusion proteins, phage display techniques.
- 4.4 Applications of gene cloning – Identifying and analyzing mRNA, analyzing gene *in situ*, analyzing promoter protein interactions, transgenics, detecting DNA polymorphism, DNA chip technology.

Semester –III

Paper-XII, Special Group-Cell Biology-II

Unit I

- 1.1 Chromosome structure and classification – Human karyotyping and criteria for ideogram preparation. Chromosome banding methods, it's applications in genetics.
- 1.2 Chromosomal mutations, molecular mechanism of mutation. Structural abnormalities of human chromosomes and related syndromes: Deletion, Robertsonian translocation, Cri-du-chat syndrome, Prader-Willi syndrome, Williams syndrome, Wolf-Herschhorn syndrome.
- 1.3 Human metabolic disorders: Phenylketonuria, Lesch-Nyhan syndrome, Tay-Sachs disease, Alkaptonuria, Albinism, Congenital adrenal hyperplasia, Emphysema, Glucose-6-phosphate dehydrogenase deficiency.
- 1.4 Molecular methods of chromosome studies and applications – *in situ* hybridization, FISH.

Unit-II

- 2.1 Genome organization – Hierarchy in genome organization. Physical and genetic mapping of genome. Organelle genome – organization and expression of mitochondrial and chloroplast genome.
- 2.2 Detailed account of genome models of lambda phage, *E. coli*, *C. elegans*, *Drosophila* and humans.
- 2.3 Functional genomics – Human genome project.
- 2.4 Molecular cytogenetic techniques – DNA fingerprinting, automated karyotyping, chromosome painting, DNA sequencing, microarray.

Unit-III

- 3.1 Sex determination–Mechanism of sex determination in *Drosophila* human.and
- 3.2 Developmental genetics–Establishment of anterior-posterior polarity and role of maternal effect genes during development.
- 3.3 Cell specification and determination–Role of segmentation genes, gap genes, pair-rule genes and segment polarity genes during development. Homeobox concept in different phylogenic groups.
- 3.4 Cell differentiation and differential gene activity, totipotency and nuclear transfer experiment.

Unit-IV

- 4.1 Population genetics – Demes, gene pool, gene flow and genetic drift. Hardy-Weinberg equation and it's significance in population genetics.
- 4.2 Genetic selection–Selection pressure, fitness and coefficient of selection, types and examples of genetic selection.
- 4.3 Speciation and isolating mechanisms.
- 4.4 Theories of organic evolution.

Semester-III, Practical-VI, Special Group- Cell Biology

Section- A

1. Histochemical demonstration of Mitochondria
2. Histochemical demonstration of Golgi complex
3. Histochemical demonstration of Lactate dehydrogenase
4. Histochemical demonstration of Succinate dehydrogenase
5. Isolation and characterization of Nuclei from liver
6. Isolation and characterization of Mitochondria
7. Isolation of DNA from any tissue
8. Separation of lipids using thin layer chromatography
9. Separation of various proteins using column chromatography
10. Study of metaphase chromosomes from rat bone marrow
11. G banding of metaphase chromosomes
12. C- banding of metaphase chromosomes
13. Estimation of Mitotic Index
14. Measurement of cell size using oculometer.

Distribution of Marks	Marks
1. Histochemical demonstration of mitochondria/ Golgi bodies/ Lactate dehydrogenase/ Succinate Dehydrogenase	15
2. Separation of lipids using thin layer chromatography/ Proteins using column chromatography	20
3. Demonstration metaphase chromosomes / G banding/C banding	15
4. Measurement of cell size oculometer/ isolation & characterization of nuclei/ DNA.	15
5. Class record and submission	10
6. Viva- voice	05

	80
Internal Assessment	20

Total marks	100

Semester –III

Paper-XI, Special Group-Fresh water Zoology -I

Limnology

Unit-I

- 1.1 Dynamics of Aquatic Ecosystems (predators, consumers, decomposers, transformers, ecological pyramids & trophic levels), Energy flow models.
- 1.2 Lotic Habitat : Major river systems in India.
- 1.3 Lentic Habitat : Lakes and their origin
- 1.4 Bog lakes & succession of lakes, man-made lakes and reservoirs

Unit-II

- 2.1 Physical conditions of water: Movement of water, Viscosity, Density.
- 2.2 Buoyancy, Surface film and surface film animal.
- 2.3 Temperature and Light, Transparency and turbidity.
- 2.4 Influence of physical conditions on pH of surface and bottom water.

Unit-III

- 3.1 Chemical conditions of water: Dissolved oxygen & carbon dioxide
- 3.2 Phosphates, Nitrates & Silicates.
- 3.3 Hardness: Total Hardness, Mg - hardness & Ca – Hardness.
- 3.4 Nitrogen and Ammonia, Importance of Chemical Parameters.

Unit-IV

- 4.1 Primary and secondary productivity in aquatic ecosystems.
- 4.2 Classification of waterbodies based on productivity.
- 4.3 Methods of measurement of productivity.
- 4.4 Factors affecting primary productivity and significance of productivity studies

Semester-III

Paper-XII, Special Group-Fresh water Zoology-II Fishery Biology

Unit-I

- 1.1 Schemes of classification of fishes by Berg (1940) and Romer (1971).
- 1.2 Biology of Indian major carps and culturable exotic carps.
- 1.3 Food and feeding habits of some common fresh water fishes.
- 1.4 Methods of gut content (food) analysis.

Unit-II

- 2.1 Structure and function of gills.
- 2.2 Electroreceptors in fishes and their functions.
- 2.3 Growth and age studies on fish
- 2.4 Length- weight relationship and condition factor.

Unit-III

- 3.1 Maturation, spawning periodicity and fecundity of fish.
- 3.2 Maturity stages of male & female fish, and atretic follicles.
- 3.3 Genetic engineering methods for fish stock improvement.
- 3.4 Fish diseases caused by pathogens and parasites.

Unit-IV

- 4.1 Aquarium-fish keeping and its maintenance.
- 4.2 Breeding of ornamental fishes - egg depositors and live bearers.
- 4.3 Exotic and larvivorous fishes and their importance
- 4.4 Threatened fresh water fishes and conservation measures.

Semester –III Practical-VI, Special Group- Fresh water Zoology

- 1) Morphometric determination of a water body.
- 2) Analysis of water: pH, Transparency, Turbidity, Dissolved Oxygen (DO), free carbon dioxide, Alkalinity(Carbonates & Bicarbonates), Hardness (Total, Ca & Mg), Chlorides, Phosphates, Nitrogen (Ammoniacal), Nitrates, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD).
- 3) Determination of primary productivity of a water body by light and dark bottle method.
- 4) Identification of commercially important freshwater fishes and prawns.
- 5) Morphometric study of fish.
- 6) Determination of age of fish by scale method.
- 7) Determination of spawning periodicity by ova diameter / gonadosomatic index
- 8) Gut content analysis and determination of feeding intensity.
- 9) Determination of length - weight relationship and condition factor.
- 10) Estimation of fecundity and study of maturity stages of fish.
- 11) Study of histological slides of fish.
- 12) Identification of common parasites of fish.
- 13) Dissection of accessory respiratory organs & reproductive system of fish.
- 14) Permanent mounting of fish scales.
- 15) Visit to a fresh water body for the study of aquatic ecosystem.

Distribution of marks	Marks
1) Water analysis: Major expt. / Primary productivity determination	15
2) Water analysis: Minor expt.	10
3) Determination of spawning periodicity / Length - weight relationship / Gut content analysis / Morphometry of fish.	10
4) Estimation of Fecundity / Feeding intensity/ Condition factor	05
5) Identification of spots (1 to10)	20
6) Dissection of accessory respiratory organs or reproductive system / Permanent mounting of scale	05
7) Practical record & submission of slides	10
8) Viva – voce	05

	80
Internal Assessment	20

Total marks	100

Semester-III

Paper-XI, Special Group-Aquaculture-I

Fresh water Aquaculture

Unit-I

- 1.1 Aquaculture: Definition, importance and present status in India.
- 1.2 Physicochemical conditions of pond water.
- 1.3 Biological conditions – Aquatic vegetation, Association of macro vegetation.
- 1.4 Plankton: Seasonal distribution, Diurnal movement and its role in fisheries.

Unit-II

- 2.1 Pond soil, Chemical conditions.
- 2.2 Pond ecosystem: Trophic level, food chain and food web in pond.
- 2.3 Methods of productivity measurement.
- 2.4 Planning and construction of fresh water fish farm.

Unit-III

- 3.1 Biology of culturable indigenous carps.
- 3.2 Biology of culturable exotic carps.
- 3.3 Reproductive system and breeding behavior in Indian carps.
- 3.4 Fisheries of major river systems in India.

Unit-IV

- 4.1 Reverine collection of fish seed.
- 4.2 Fish breeding in wet and dry bundhs.
- 4.3 Induced breeding by hypophysation.
- 4.4 Hatching techniques and types of hatcheries.

Semester –III
Paper-XII, Special Group-Aquaculture-II

Aquaculture and Rural Development

Unit-I

- 1.1 Culture of zooplankton
- 1.2 Prawn culture & Methods of breeding
- 1.3 Culture of crabs
- 1.4 Pearl culture / Oyster culture

Unit-II

- 2.1 Development and advancement of aquaculture in India.
- 2.2 Larvivorous fishes in relation to public health.
- 2.3 Culture of Exotic and transplanted fishes
- 2.4 Breeding and care of fresh water aquarium fishes.

Unit-III

- 3.1 Definition of economics and application of economic principles to aquaculture.
- 3.2 Aquaculture and rural development in India.
- 3.3 Role of FFDA in development of aquaculture in India.
- 3.4 Fishery extension techniques.

Unit-IV

- 4.1 Socio-economic status of fishermen community.
- 4.2 Fisheries co-operatives and their role in fish production and marketing.
- 4.3 Organization and operational problems in fisheries co-operative societies.
- 4.4 Fishery legislation and their role in fishery development.

Semester-III, Practical-VI, Special Group- Aquaculture

- 1) Physicochemical analysis of pond water for determination of pH, Turbidity, DO, Free CO₂, Ammonia, Alkalinity, Hardness, Nitrates and Phosphates.
- 2) Physicochemical analysis of pond soil to determine its texture, pH, particle size, available nitrogen, phosphorus and free CaCO₃.
- 3) Qualitative and quantitative study of plankton and benthos.
- 4) Study of food chain in fresh water pond ecosystem.
- 5) Estimation of primary productivity by light and dark bottle method.
- 6) Collection and identification of local fish fauna.
- 7) Identification and classification of Indian and exotic carps.
- 8) Estimation of fecundity.
- 9) Dissection of carp / catfish to collect pituitary.
- 10) Preparation of fish pituitary extract and detection of doses for injection.
- 11) Visit to a fish seed hatchery.

Distribution of marks	Marks
1) Analysis of pond water	15
2) Analysis of pond soil	10
3) Quantitative analysis of plankton / detection of primary productivity.	10
4) Estimation of Fecundity	05
5) Identification of spots (1 to10)	20
6) Dissection / Permanent mounting	05
7) Practical record & submission	10
8) Viva – voce	05

	80
Internal Assessment	20

Total marks	100

Semester –III

Paper-XI, Special Group-Environmental Biology-I

Ecosystems and Communities

Unit-I

- 1.1 Ecosystem: Structure and functions of marine and freshwater ecosystems, grassland, desert and forest ecosystems, abiotic and biotic components of ecosystems.
- 1.2 Energy flow: Y shaped and universal model.
- 1.3 Food chain, food web, ecological pyramid-types and diversity.
- 1.4 Planktons: nature, distribution, seasonal succession, beneficial and harmful effects, qualitative and quantitative estimation

Unit-II

- 2.1 Nekton, Benthos : nature, distribution and analysis, Periphyton- definition, collection, preservation and importance.
- 2.2 Eutrophication: Definition, types, effects and control measures.
- 2.3 Biogeochemical Cycles in Nature- Gaseous Cycles: Water, Carbon and Oxygen cycle.
- 2.4 Sedimentary Cycles in nature- Nitrogen, sulphur and Phosphorus cycles.

Unit-III

- 3.1 Productivity: concept, Primary and secondary productivity, measurement of productivity by light and dark bottle method, factors affecting primary and secondary productivity.
- 3.2 Biotic community: definition, concept and characteristics of community, community structure, stratification and periodicity, ecotone and edge effect.
- 3.3 Ecological niche, ecotype, ecophene and ecological indicators.
- 3.4 Ecological succession: definition, types and process of ecological succession, significance.

Unit –IV

- 4.1 Biosphere: Major biomes of the world with emphasis on Indian biomes.
- 4.2 Biometeorology: scope and factors
- 4.3 Water and soil as essential factors for the meteorological studies.
- 4.4 Radiant energy, temperature and light.

Semester –III

Paper-XII, Special Group- Environmental Biology-II

Adaptations, Population dynamics, and Animal Behaviour

Unit-I

- 1.1 Adaptations of animals with reference to physical conditions: temperature and light.
- 1.2 Chemical conditions: oxygen, carbon dioxide.
- 1.3 Physiological process: osmoregulation and thermoregulation.
- 1.4 Physiological process: Bioluminescence and Echolocation.

Unit-II

- 2.1 Influence of physical environment on organism: viscosity, surface tension, salinity, pressure, buoyancy and surface film animals.
- 2.2 Biological Rhythms: photoperiodism, biological clock, annual and lunar periodicity.
- 2.3 Mimicry and protective colouration: definition of mimicry, kinds of mimicry.
- 2.4 Batesian and Mullerian mimicry and significance.

Unit-III

- 3.1 Population dynamics: population structure, pattern of population distribution, population growth and density relationship, population fluctuations and dispersal of population.
- 3.2 Dispersal: Barriers of dispersal, means of dispersal, migration.
- 3.3 Interspecific relationship: mutualism, commensalism, parasitism, synergism, antagonism and competition.
- 3.4 Prey and Predator relationship

Unit-IV

- 4.1 Intraspecific relationship: aggregations and social organization.
- 4.2 Animal behavior: innate or inherent behavior, learned behavior, vision and behavior, sound and behavior.
- 4.3 Social behaviour: mating, family, and group behavior, advantages of social behavior
- 4.4 Genetic, hormonal and evolutionary aspects of behavior.

Semester –III, Practical-VI, Special Group-Environmental Biology

1. Sampling of water determination of pH, temperature and turbidity.
2. Plankton study- collection and analysis of zooplanktons (Quantitative and qualitative analysis)
3. Identification of crustaceans, insects, snails from fresh water / lake / pond
4. Identification of common aquatic weeds, predatory fishes and harmful insects from the pond.
5. Study of indication of pollution - estimation of BOD and COD.
6. Determination of primary productivity by light and dark bottle method.
7. Estimation of dissolved oxygen in water sample by Winkler's method.
8. Estimation of carbon dioxide from given water sample.
9. Determination of relative humidity by hygrometer / psychrometer.
10. Determination of wind velocity by anemometer.
11. Physico-chemical analysis of water for determination of alkalinity, hardness, nitrites and phosphates.
12. Estimation of Sodium and potassium by flame photometry.
13. Identification of benthic and periphytonic organisms.

Distribution of Marks	Marks
1. Major experiment	15
2. Minor experiment	10
3. Minor experiment	10
4. Identification and comment on given spots (1-10)	30
5. Class record	10
6. Viva voce	05

	80
Internal Assessment	20

Total marks	100

Semester –III
Paper-XI, Special Group-Sericulture-I

Moriculture

Unit-I

- 1.1 Sericulture : Definition, history, present status of sericulture industry in India, economic importance.
- 1.2 Silkworms : Systematic position, types of silkworm, their host plants and geographic distribution.
- 1.3 Problems and prospects of sericulture in India
- 1.4 Sericulture Extension: Principles and importance of extension education in sericulture, methods of sericulture extension.

Unit-II

- 2.1 Economics of Sericulture: Economics of mulberry cultivation, cocoon production, silkworm rearing, silk reeling and processing.
- 2.2 Sericulture Organizations: Central Silk Board, Directorate of Sericulture at state level, role of sericulture organization in extension of sericulture.
- 2.3 Marketing and Management of Sericulture: Marketing of cocoons and raw silk yarn, traditional and regulated markets.
- 2.4 Silk exports - challenges and growth.

Unit-III

- 3.1 Mulberry Plant : Taxonomy and morphology of mulberry plant, anatomy of leaf, root, stem and flowers, mulberry varieties.
- 3.2 Mulberry Cultivation : Selection and preparation of land, climate and soil conditions for mulberry cultivation, propagation of mulberry, manuring and irrigation, intercultivation and pruning.
- 3.3 Pests of Mulberry : Identification, classification, life cycle, nature of damage and control measures of pests of mulberry - bihar hairy caterpillar, jassids, mealy bugs, thrips, stem borers, gall midge.
- 3.4 Diseases of Mulberry : Factors, symptoms, disease cycle and control measures of diseases of mulberry - leaf spot, powdery mildew, red rust, root knot, common mulberry dwarf.

Unit-IV

- 4.1 Physiology : Mineral nutrition, photosynthesis, respiration, growth regulators, photoperiodism and transcription.
- 4.2 Genetics of Mulberry : Spontaneous and induced mutation, molecular basis of DNA damage and repair, biological diversity in mulberry. Germplasm conservation - methods, centres of collection and significance.
- 4.3 Cytogenetics of mulberry, genetic control of disease resistance in mulberry.
- 4.4 Breeding of Mulberry : Breeding of mulberry for drought resistance, application of tissue culture in mulberry breeding, hybridization and selection of mulberry for genetic improvement. Pure line clonal and mass selection - application, advantages and limitations. Evaluation of mulberry genotype - Primary, secondary and multilocational traits.

Semester –III

Paper-XII, Special Group- Sericulture-II

Mulberry and non mulberry silkworms

Unit-I

- 1.1 Mulberry Silkworm : Classification, geographical distribution and life cycle of *B. mori*
- 1.2 Moultnism and Voltinism : Univoltine, bivoltine and multivoltine races.
- 1.3 Morphology : Morphology of egg, larva, pupa, adult, mouth parts of larva, sexual dimorphism.
- 1.4 Anatomy : Silk gland, digestive, circulatory, respiratory, excretory, male and female reproductive system, neuroendocrine system and sense organs.

Unit-II

- 2.1 Physiology : Physiology of digestion, excretion, respiration; mechanism of circulation, silk synthesis and diapause.
- 2.2 Neuroendocrine system - neurosecretory cells, corpora allata, corpora cardiaca, ecdyicial gland. Hormonal control of moulting and metamorphosis. Exocrine glands and pheromones.
- 2.3 Pests of Silkworm, *B. mori* : Identification, classification, life cycle and control measures of invertebrate pests (Uzi fly, dermestid beetle, ant, praying mantis, mites) and vertebrate pests (Lizzard, bird, squirrel, rat) of silkworm.
- 2.4 Diseases of Silkworm, *B. mori* : Etiology, structure, symptoms, pathogenesis and diagnosis of diseases - pebrine, grasserie, flacherie and muscardine.

Unit-III

- 3.1 Tasar Silkworm : Distribution, life cycle and food plants.
- 3.2 Anatomy of Tasar Silkworm : Silk gland, digestive, respiratory and reproductive system.
- 3.3 Rearing of tasar silkworm and reeling of cocoons.
- 3.4 Pests and diseases of tasar silkworm.

Unit-IV

- 4.1 Distribution, life cycle and food plants of muga silkworm.
- 4.2 Rearing of muga silkworm and reeling of cocoon.
- 4.3 Distribution, life cycle and food plants of eri silkworm.
- 4.4 Rearing of eri silkworm and reeling of cocoon.

Semester –III, Practical-VI, Special Group-Sericulture

1. Study of external morphology of the egg, larva, pupa and adult of different silkworm types, sexual dimorphism in larva, pupa and adults.
2. Study of life history of different silkworm types.
3. Dissection of digestive system, silk gland, nervous system, circulatory system and mouth parts of larva. Reproductive system of larva and adults.
4. Identification of the locally available varieties of mulberry.
5. Preparation of herbarium of the locally available non-mulberry host plants.
6. Study of the anatomy of leaf, stem, root and petiole of different locally available varieties of mulberry.
7. Propagation of mulberry through cutting, grafting and layering.
8. Analysis of organic, inorganic contents and pH of the soil.
9. Collection, preservation, identification and economic importance of the local pests of mulberry silkworm.
10. Collection, preservation, identification and economic importance of the locally found pests and diseases of mulberry.
11. Identification of diseases of mulberry silkworm.

Distribution of marks

Marks

1. Dissection	15
2. Identification and Comment on the spots (1-5)	15
3. Temporary slide preparation (Mouth parts/plant structure	05
4. Characteristics of mulberry leaves of different varieties and their stomatal frequency.	10
5. Analysis of soil (test report)	10
6. Submission of Tour diary and herbarium	10
7. Practical record	10
8. Viva voce	05

80

Internal Assessment

20

Total marks

100

Semester-IV

Paper-XIII, Biotechniques, Biostatistics and Ethology

Unit-I

- 1.1 Sterilization techniques, media for microbial culture, inoculation methods.
- 1.2 Animal cell & tissue culture- primary culture, cell lines, cell quantification, growth kinetics of cells in culture, cryopreservation of cells.
- 1.3 *In vitro* fertilization technology, cloning, socio-ethical issues of cloning.
- 1.4 Cell separation by Flowcytometry.

Unit-II

- 2.1 Basic principle of sedimentation, Preparative centrifugation, analytical centrifugation and applications of ultracentrifugation in cell fractionation.
- 2.2 Radioactive isotopes, half lives of radioisotopes, isotope techniques in biology and autoradiography.
- 2.3 Chromatographic separation: Thin layer and gas chromatography, High performance liquid chromatography (HPLC).
- 2.4 Electrophoretic separation techniques.

Unit-III

- 3.1 Introduction to statistics and Biostatistics- history, subdivision of statistics, data type, steps in statistical methods, Graphical representations of data in tabular form, characteristic and classification of table, line chart, histogram, bar diagram, pie diagram, cumulative frequency tables and diagrams.
- 3.2 Central tendency and dispersion-Descriptive statistics, central tendency, mean, median and mode with examples, dispersion, and variance.
- 3.3 Probability and probability distribution -Basic theory and type of probability and probability distribution with example (binomial, poisson and normal distribution).
- 3.4 Sampling – types, standard error (SE), standard deviation (SD), significance tests - t- test, z- test, Chi square test- assumption, importance and example.

Unit-IV

- 4.1 Population ecology- population structure, distribution, growth, density, fluctuation and dispersal.
- 4.2 Orientation, navigation and homing.
- 4.3 Neuronal control, genetic and environmental components in development of animal behaviour.
- 4.4 Animal ethics- Introduction, concept, organizations and their functions.

Semester-IV

Paper-XIV, Toxicology and Bioinformatics

Unit-I

- 1.1 Introduction and Scope of Toxicology
- 1.2 Principles of Testing for Toxic Effects
- 1.3 Absorption, Distribution, Metabolism and Excretion of Toxicants
- 1.4 Mechanisms of Toxicity-receptor concept, nature of receptors, theory of toxicant receptor inter action and mechanism of action.

Unit-II

- 2.1 Environmental toxicants-Pesticides, Fertilizers, Heavy and trace metals, radioactive substances, food additives, Automobile emission, their accumulation, residual effects distribution in body and excretion
- 2.2 Toxicants at organ and system level- Tetratogens- causes, mode of action and evaluation.
- 2.3 Nutritional toxicology- Potential toxicants in foodstuff, natural toxic compound, Industrial contaminants, food additives, liver function test in toxicology and Antidotal procedure (type of intoxication, administration of antidotes and chelation theory)
- 2.4 Physiological and Biochemical Impact of toxicants on aquatic organisms.

Unit-III

- 3.1 Scope of bioinformatics - history, scope of bioinformatics in research, business and employment opportunities.
- 3.2 Bioinformatics and internet.
- 3.3 Human genome project and online Mendelian inheritance in man (OMIM).
- 3.4 Bioinformatics in India- current status and future implication.
- 3.5 Databases - content, structure and annotation and type of databases.

Unit-IV

- 4.1 Biological databases retrieval tools and systems – sequence similarity searches, FASTA, BLAST, interactive databases searches and PSI-BLAST.
- 4.2 Multiple sequence alignment and family relationships.
- 4.3 Protein domain family and protein databases.
- 4.4 Phylogenetics analysis- tree styles, tree building method, evolution of macromolecular sequence tools for making and drawing trees (phylip and clustlw).

• Suggested Readings

Tissue culture and Biotechniques

1. Animal cell culture – A practical approach, (III Edition) Ed. John R. W. Masters. IRL Press.
2. *In vitro*-cultivation of animal cell, biotechnology by open learning (BIOTOL), Butterworth Heinemann Ltd. Linaere house, Jordan Hill Oxford.
3. Introduction to instrumental analysis, Robert Broun, McGraw Hill International Edition.
4. A Biologist Guide to Principle and Techniques of Practical Biochemistry K. Wilson and K.H. Goulding ELBS Edition.
5. Molecular Cell Biology, J. Darnel, H. Lodish and D. Baltimore. W. H. Freeman and Company New York.
6. DNA Techniques by Alcamo.
7. Insect Cell Culturing Engineering, Ed. M. F. A. Goosen, A.J. Daugulis and P.Faulkner.
8. Biotechnology - B. D. Sings.
9. Biophysical Chemistry – Upadhyay, Upadhyay and Nath.

Toxicology

1. Animal Clinical Chemistry: A Primer for Toxicologists. G.O. Evans (Ed.) ISBN: 0748403515, Taylor & Francis, 1996.
2. Animal Models in Toxicology. S.C. Gad & C.P. Chengelis (Eds.), ISBN: 0824784561, Marcel Deker, 1992.
3. Annual Reviews of Pharmacology & Toxicology, ISBN: 0824304373, 1997
4. Basic Toxicology: Fundamentals, Target Organ & Risk Assessment. F.C. Lu, ISBN: 1560323809, Taylor & Francis, 1996.
5. Casarett & Doull's Toxicology: The Basic Science of Poisons. C.D. Klaassen (Ed), ISBN: 0071054766, McGraw-Hill, 1996.
6. Comprehensive Toxicology. I. Sipes, C.A. McQueen & A. Gandolfi (Eds.), ISBN: 0080423019, Elsevier Science, 1997.
7. General & Applied Toxicology. B. Ballantyne, T. Mars & P. Turner (Eds), Vol I & II, ISBN: 0333498011, Macmillon/Stockton Press, 1993.

8. Loomi's Essentials of Toxicology, T.A. Loomis & A.W. Hayes, ISBN: 0124556256, Academic Press, 1996.
9. Encyclopaedia of Toxicology, Chemical and Concepts, P. Wexler, ISBN: 012227220-X, Academic Press, 1998.
10. Dictionary of Toxicology. E. Hogson, J.E. Chambers & R.B. Mailman, ISBN: 1561592161, Groves ic, 1997.

Biostatistics

1. Biostatistics-Arora and Malhan
2. Biostatistics- Jasraj and Gurudeep Raj
3. Biostatistics- P. Ramkrishan
4. Methods in Biostatistics-Mahajan

Bioinformatics

1. Mount W. 2004. Bioinformatics and sequence genome analysis 2nd Edition CBS Pub. New Delhi.
2. Bergman, N. H. Comparative Genomics. Humana Press Inc. Part of Springer Science+BusinessMedia, 2007.
3. Baxevanis, A. D. Ouellette, B. F. F. 2009. Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
4. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings.
5. Des Higgins and Willie Taylor 2000. Bioinformatics: Sequence, structure and databanks. Oxford University Press.
6. Rashidi H. H. and Buehler 2002. Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London.
7. Gibas Cynthia and Jambeck P. 2001. Developing Bioinformatics Computer Skills: Shroff Publishers and Distributors Pvt. Ltd. (O'Reilly), Mumbai.

Semester-IV

Paper-XV, Special Group-Entomology-III

Sense organs, social life and Agriculture pests

Unit-I

- 1.1 Compound eyes- structure and functions.
- 1.2 Ocelli- structure and functions.
- 1.3 Sound producing organs: Structure and physiology.
- 1.4 Light producing organs: Structure and bioluminescent mechanism.

Unit-II

- 2.1 Mechanoreceptors: Sensory hairs, campaniform sensilla and chordotonal organs.
- 2.2 Tympanal organs, Johanson's organ, Chemoreceptors- sensilla trichoidea, sensilla basiconica.
- 2.3 Pigments and mechanism of colour change, mimicry and camouflage.
- 2.4 Immunity in insect: Innate immunity and molecular mechanism.

Unit-III

- 3.1 Social life: Polymorphism, nest building and social behavior in Isoptera.
- 3.2 Social life: Polymorphism, nest building and social behavior in ants.
- 3.3 Parasitic Hymenoptera-types and significance.
- 3.4 Locust migration and swarming.

Unit-IV

- 4.1 Pest of major crops: Rice, Cotton and Sugarcane-classification, life history, damage and control.
- 4.2 Pest of fruits: Citrus and Mango-classification, life history, damage and control.
- 4.3 Pest of vegetables: Cabbage and Brinjal- classification, life history, damage and control.
- 4.4 Stored grain pests: classification, life history, damage and control measures.

Semester-IV

Paper-XVI, Special Group-Entomology-IV

Pest control measures and Insects vectors

Unit-I

- 1.1 Inorganic insecticides: Properties, mode of action and use.
- 1.2 Chlorinated Hydrocarbons: Properties, mode of action and use.
- 1.3 Organophosphates: Properties, mode of action and use.
- 1.4. Natural organic compound and pyrethroids: Properties, mode of action and use.

Unit-II

- 2.1 Biological control: Historical and theoretical basis of biological control.
- 2.2 Desirable attributes of natural enemies of pests.
- 2.3 Parasitoids used in biological control programmes: life cycle and biological relationship.
- 2.4 Predators used in biological control programmes: life cycle and biological relationship.

Unit-III

- 3.1 Insect pathogenic bacteria used in biological control programmes, biological relationship, mass production and examples.
- 3.2 Insect pathogenic viruses used in biological control programmes, biological relationship, mass production and examples
- 3.3 Use of radiation, chemosterilants, hormones and pheromones in pest control programmes.
- 3.4 Integrated pest managements: principles, modeling, application and examples.

Unit-IV

- 4.1 Pest of horse and cattle: Nature of damage, life cycle and control measures.
- 4.2 Mosquitoes causing disease in man: Pathogens, diseases, mode of transmission and control.
- 4.3 Flies causing disease in man: Pathogens, diseases, mode of transmission and control.
- 4.4 Lice and fleas causing disease in man: Pathogens, diseases, mode of transmission and control.

Semester-IV, Practical-VII, Special Group-Entomology

1. Dissection of silk gland in mulberry and non mulberry silkworms.
2. Dissection of male and female reproductive system in silk moths.
3. Dissection of salivary, pharyngeal glands and sting apparatus in honey bees.
4. Demonstration of disease causing pathogens in insects.
5. Permanent histopathological preparations of baculovirus and protozoan infected tissues.
6. Insect collection-preservation, identification, classification of harmful insects, parasitic hymenopteran and other beneficial insects.
7. Whole mount preparations of parasitic insects and microscopic pests.

8. Determination of Lethal dose (LD₅₀) of pesticide.
9. Preparation of life history of economical important insect.
10. Compulsory visit to Apiculture, Sericulture, Lac culture centers and entomology research laboratory/center.

Distribution of Marks:

	Marks
1. Dissection	15
2. Identification, classification and economic importance of spots (1 to 10)	20
3. Demonstration of microbial pathogen in insect	10
4. Whole mount preparation	10
5. Class record and submission of slides	10
6. Submission of life history	10
7. Viva-voce	05

80

Internal Assessment

20

Total marks

100

- **Project work** 100
(80 marks project evaluation including viva + 20 marks Internal assessment)
- **Suggested Readings**

Entomology

1. Imms General text book of Entomology, Eds. O. W. Richards and R. G. Davis Chapman and Hall, London.
2. General and Applied Entomology, K.K. Nayar, T. N. Ananthkrishan and B.V. Davis Tata McGraw -Hill Co.Ltd. Bombay.
3. The Insect: Structure and function, R.F. Chapman, Cambridge University Press.
4. The Physiology of Insect , Ed. M.Rockstein ,Vol, 1-5, Academic Press, New York.
5. The Physiology of Insect Reproduction, F, Englemann, Pergamon Press, New York.
6. Comprehensive Insect Physiology , Biochemistry and Pharmacology , Eds. G.A. Kerkut and I. A. Gillberd, VOL. 1-13, Pergamon Press, New York.
7. Analytical Biochemistry of Insect, Ed. R. B. Turner, Elsevier, Amsterdam.
8. Insect Hormone, M. J. A. Novak. Chapman and Hall, London.
9. Modern Entomology(Second edition): D. B. Tembhare, Himalaya Publication House, Bombay.
10. Destruction and Useful Insect, Their Habits and Control, C. L. Metcalf, W. P. Flint and R. I. Metcalf, Mc Grow I Ill Co. New York.
11. Integrated Pest Management, J.L. Apple and R. E. Smith, Plenum Publication Co., New Delhi.
12. An Introduction Of Biological Control RVD Boarscho, P. S. Y. Messenger and A. P. Gaiter, Plenum Publication Co.
13. Text Book of Entomology, K. P. Shivastava, Vol. 1 And 2 Kalyani Publication, Ludhiana.
14. Agriculture Entomology, H. S. Dennis, Timber Press Inc.

15. Entomology and Pest Management, Larry P. Pedigo, Prentice Hall.
16. Text Book of Agriculture Entomology, Alford V. David, Blackwell Science.
17. Biopesticides In Insect Pest Management, S. J. Ignacimulha and Alok Sen , Phoenix Publishing House Pvt, Ltd.
18. Biotechnology in Invertebrate Pathology and Cell culture (Maramorosch, K. ed.). Academic Press, New York.
19. PEBFANS (2003)” (Solomon Raju, A. J. ed.). Andhara University Press, Visakhapatnam.
20. Living Resources for the Millennium 2000 (S. J. William ed.), Students Offset Press, Chennai.

Semester –IV

Paper-XV, Special Group-Fish and Fisheries-III

General studies

Unit-I

- 1.1 Structure of alimentary canal in teleosts; feeding habits, histology of different parts
- 1.2 Modification of alimentary canal in relation to feeding habits, digestion and absorption of food.
- 1.3 Structure of kidney in teleosts: Head kidney and trunk kidney, histology, blood supply
- 1.4 Osmoregulation in Freshwater forms, Marine forms, Rays and Skates, Diadromous fishes.

Unit-II

- 2.1 Chemoreceptors: Structure of olfactory system, morphology of peripheral olfactory organ, cellular composition of olfactory epithelium, olfactory bulb and central projections
- 2.2 Structure and functions of taste buds.
- 2.3 Migration in fishes: Types- Anadromous, Catadromous, Amphidromous, factors responsible for migration (Intrinsic and environmental), periodicity of migration.
- 2.4 Role of hormones in migration, Orientation and Navigation during migration.

Unit-III

- 3.1 Structure of male reproductive system
- 3.2 Mechanism of spermatogenesis and its hormonal control
- 3.3 Structure of female reproductive system
- 3.4 Oogenesis, egg development, hormonal control of oogenesis

Unit-IV

- 4.1 Structure, hormones and functions of pituitary gland in fishes
- 4.2 Structure, hormones and functions of other endocrine glands.
- 4.3 Structure of Hypothalamo-hypophysial system in fishes.
- 4.4 Neurohormones and their functions.

Semester –IV

Paper XVI, Special Group-Fish and Fisheries -IV

Fishery technology and Fish pathology

Unit-I

- 1.1 Pond management (siting construction and problems)
- 1.2 Gear and crafts in inland water
- 1.3 Conservation of fish, Fish legislation and their importance.
- 1.4 Water pollution and inland fisheries

Unit-II

- 2.1 Plankton in relation to fish production,
- 2.2 Culture of phytoplankton and zooplankton (Daphnia, Artemia, Monia)
- 2.3 Manufacture and maintenance of Aquarium
- 2.4 Hybridization and transgenic fish

Unit-III

- 3.1 Fish marketing: Marketing practices, information, marketing channels and systems
- 3.2 Domestic and export marketing.
- 3.3 Sex control and sex reversal under condition and chromosome set manipulation in fish
- 3.4 Gamete preservation: cryopreservation and its application.

Unit-IV

- 4.1 Methods of curing and preservation of fish.
i. Refrigeration and freezing, ii. Drying, iii. Salting, iv. Smoking, v. Canning
- 4.2 Fish products and by-products: i. Fish body oil, ii. Fish liver oil, iii. Fish meal, iv. Isinglass, v. Fish protein concentrate, vi. Fish glue, vii. Fish manure
- 4.3 Fish pathology: i) Signs of sickness and effects on fish, ii) Pathological procedure for diagnosis of fish diseases
- 4.4 Fish diseases and its control: Biotic (fungal, bacterial and viral etc.) and Abiotic.
a) Viral diseases, b) Bacterial diseases, c) Fungal diseases, d) Protozoan diseases

Semester- IV, Practical-VII, Special Group-Fish and Fisheries

1. Elementary work on surgical ablation with reference to gonads.
2. Normal differential count in fish blood.
3. Effect of stress (cold) on differential count in fish blood.
4. Effect of stress (hot) on differential count in fish blood.
5. Estimation of protein in blood serum of fish.
6. Separation of proteins based on molecular weight by SDS-PAGE.
7. Study of permanent histological slides of various fish organs & endocrine glands.
8. Skeletal system of *Wallago & Labeo*.
9. Weberian ossicles in *Heteropneustes fossilis*, *Clarius batrachus* & *Wallago*.
10. Accessory respiratory organs in some air breathing fishes.
11. Assessment of maturity of gonads.

Distribution of Marks:

	Marks
1. Surgical ablation of gonads	25
2. Minor Dissection	10
3. Physiology Experiment	15
4. Spotting	15
5. Viva voce	10
6. Practical Record	05

Internal Assessment

Total marks

80

20

100

- **Project work** 100

(80 marks project evaluation including viva + 20 marks Internal assessment)

● **Suggested Readings:**

1. Fish Physiology Vol. 1 to 13: Hoar H.S. & Randall (Eds.) (1964-1994) Academic press London, New York.
2. The physiology of fishes Vol. 1&2: Brown M.E.(1957) Academic press, New York.
3. Natural history of fishes & systematic of fresh water fishes :P Datta Munshi, J.S. & Shrivastva, M.P.(1988): Narendra pub. House, Delhi.
4. Air breathing fishes of India- Their structure, function and life history : Dutta Munshi, J. S., Hunghe G.M. (1992) .Oxford and JBH publication Co. New Delhi.
5. The freshwater fishes of India, Pakistan, Bangladesh, Burma and Shri Lanka Handbook: Jayaram, K.C. (1981): Zoological Survey of India, Calcutta.
6. Fish migration: Jones, F.R. S. (1968), E.Arnold, London
7. Aquaculture, Bardach, Ryther and Mc Lamy
8. Marine fisheries: D. K. Dal, K. V. Rao
9. Ichthyology: Lagler, K. F., Bardach, J. and Miller, R.(1977) John Wileys and sons.
10. Fish Endocrinology: Matty, A. J. (1985), Chapman and Hall, London.
11. An aid to the identification of common commercial fishes of India and Pakistan: Mishra K. S. (1982).
12. Aquaculture: The farming and husbandry of freshwater and marine organism: Bardach, J.E. (1974). Narendra Publication House, New Delhi.
13. Handbook of breeding of Indian Major Carps by pituitary hormone injection: Chonder, S. L. (1970). Satish book enterprises, Agra.
14. Diseases of fish: Duijin, C:Van Inr. (1973), life books London.
15. Fish and fisheries of India: Jhingran , V. G. (1985). Hindustan Publication Company, New Delhi.
16. Prawns and prawn fisheries of India: Kurian, C.V. and Sebastian, V. O. (19876) . Hindustan Publication Company, New Delhi.
17. The Sea food Industry: Martin, R. E.(1990). Narendra Publication House, New Delhi.
18. Ecological effects of water, applied limnology and pollutant effect: Welch, E. B. (1992).
19. A compendium of aquaculture technologies: Sinha, V.R. P.(1993). Oxford and JBH publication Co. New Delhi.

Semester-IV

Paper-III, Special Group-Mammalian Reproductive Physiology-III

Reproductive Endocrinology

Unit-I

- 1.1 Hypothalamus – Anatomy, cytoarchitecture.
- 1.2 Releasing and release inhibiting hormones.
- 1.3 Neurotransmitters and neural signals.
- 1.4 Feedback regulatory mechanism

Unit-II

- 2.1 Adenohypophysis : Anatomy, cytology.
- 2.2 Neurohypophysis : Anatomy, cytology.
- 2.3 Gonadotrophic hormones: structure, mechanism of secretion and function.
- 2.4 Anatomy and hormones.

Unit-III

- 3.1 Hypothalamo – hypophyseal testis axis
- 3.2 The Androgen: Biosynthesis, mode of action, transport and functions of testosterone.
- 3.3 Physiology of inhibin-biosynthesis, mode of action and functions.
- 3.4 Hypothalamo – hypophyseal thyroid-gonad axis.

Unit- IV

- 4.1 Hypothalamo – hypophyseal ovarian axis.
- 4.2 The oestrogen : Biosynthesis, mode of action, transport and functions.
- 4.3 The progesterone: Biosynthesis, mode of action, transport and function.
- 4.4 Hypothalamo- hypophyseal adrenal-gonad axis.

Semester-IV

Paper-IV, Special Group-Mammalian Reproductive Physiology-IV

Reproductive Toxicology, Embryology and Fertility

Unit-I

- 1.1 Chemical toxicants and Testicular toxicity.
- 1.2 Environmental factors and reproductive health.
- 1.3 Induction of gonadal toxicity in females.
- 1.4 Interruption of pregnancy by pesticides.

Unit-II

- 2.1 Implantation of mammalian blastocyst.
- 2.2 Development of chorio–allantoic placenta.
- 2.3 Foetal membranes – Development, structure, function of chorion, amnion, allantois, yolk sac.
- 2.4 Onset and endocrine control of parturition.

Unit-III

- 3.1 Intrauterine and intra cervical devices (IUDS and IUCDS) medicated and non-medicated IUD's, Long acting steroidal contraceptives.
- 3.2 Surgical sterilization and medical termination of pregnancy (MTP).
- 3.3 Pregnancy vaccine (anti-HCG, Antizona, vaccine, immunization with FSH).
- 3.4 Recent advances in female contraception (inhibin, prostagladin, hormone analogues, subdermal implants).

Unit- IV

- 4.1 Vasectomy and reversible vas occlusion.
- 4.2 LH-RH antagonist, estrogen antagonist, GnRH antagonist.
- 4.3 Anti-androgen and anti-spermiogenic compounds (LDH-Cy and Sp-10), Inhibin.
- 4.4 Antibodies for acrosomal enzymes and sperm surface proteins.

Semester-IV, Practical-VII, Special Group-Mammalian Reproductive Physiology

1. Surgical operation in rat/mice
Ovariectomy or Hysterectomy or Unilateral adrenalectomy.
2. Dissection of female reproductive system of rat or mice and its description.
3. Vaginal smear : Vaginal cytology with relation to oestrous cycle.
4. Basal body temperature to determine time of ovulation and safe period.

5. Pregnancy detection test
6. Histochemical localization of proteins in rat / mouse thyroid by Mercury-Bromophenol blue method
7. Histochemical localization of lipids in rat / mouse ovary by Sudan Black–B method (Propylene glycol method).
8. Experimental (Histological slides for identification).
 - a. Effects of ovariectomy and oestrogen replacement on pituitary, uterus and vagina.
 - b. Effects of some female antifertility drugs on ovary and adrenal gland.
9. Histology : (Identification of slides) Histological changes in female reproductive organs during different phases of oestrous cycle in continuous and seasonal breeder.
10. Embryology : Study of various stages of development of mammalian egg, development of foetal membranes, different types of placenta, progestational changes in uterus.
11. Field work :
 - a. Visit to laboratory for embryo transfer and family planning clinics.

Distribution of marks

	Marks
1. Surgical operation	15
2. Dissection	15
3. Vaginal smear and oestrous cycle stages	10
4. Experimental analysis	10
5. Identification and comment on spots	15
6. Practical Record	10
7. Viva voce	05

80

Internal Assessment

20

Total marks

100

• **Project work**

100

(80 marks project evaluation including viva + 20 marks Internal assessment)

• **Suggested Readings**

1. A textbook of in vitro fertilization and assisted reproduction edited by P.R. Brinsden and P. A. Rainsbur Jaypee brothers 1992.
2. Advances in Reproductive Physiology, Vol. 1 to 6 : McLaren, (1968). Logos Press Ltd., London.
3. Advances in Reproductive Toxicology eds. S. C. Joshi and A. S. Ansari Pointer publishers.
4. Andrology. 2nd Edition Male Reproductive health and dysfunction (Eds. E. Nieschlag & H.M. Behre) 2000.
5. Biochemistry of Mammalian Reproduction : Zanveld, L.J.D. & R.T. Chatterton (1982). John Wiley & sons, New York. The Ovary. Vol. I, II & III : Zuckerman, S, (1962). Academic Press, London.
6. Biology of Gestation : Assalye, N.S. (1968). Academic Press, London.
7. Biology of ovarian follicles in mammals (1985). S. S. Guraya Springer-Verlag.
8. Comparative cellular and molecular biology of testis in vertebrates (Trends in endocrine, paracrine and autocrine regulation of structure of functions) (2001) S.S. Guraya, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta.
9. Comparative Endocrinology and Reproduction. Eds. K.P. Joy, A. Krishna and C. Haldar, Narosa Publishing House (1998).

10. Contraceptive Technology Past, Present and Future : Das. R.P. (1989). N.I.H.F.W. New Delhi.
11. Control of ovulation : Crighton, D.B., Haynes, N.B. Foxcroft, G.R. & G.E. Lamming (1978). Butterworths, London.
12. Encyclopedia of Reproduction Vol. I, II, III, IV eds. Ernst Knobil and J.D. Neill (1998).
13. Endocrinology and metabolism. 4th edition 2001. Philip Felig & Lawrence A. Frohman McGraw Hill Inc. Medical Publishing Division.
14. Endocrinology. Vol. 1 to 3 : L.J. Degroot et al. (1989). W.B. Saunders Co. Philadelphia.
15. General Endocrinology : Turner, C.D. & J.T. Bagnara (1990) W.B. Saunders Co., & Toppan Co., Philadelphia, London & Tokyo.
16. Hormonal Control of Lactation : Cowie, A.T. Forryth, I.A. and I. Hart (1980). Springer-Verlag, Berlin & New York.
17. Mammalian Oviduct : Hafez, E.S., and R.J. Blandu. The University of Chicago Press, Chicago, London.
18. Marshall's Physiology of Reproduction. 4th Edition Vol. 3 Pregnancy and Lactation Part I, II, III edited by G.E. Lamming, Champan and Hall.
19. Ovarian Cycle of Mammals : Perry, J.S. Oliver and Boyd, Edinburgh.
20. Patterns of Reproduction : Asdell, S.A. (1964). Constable and Co. London.
21. Physiology of Lactation : Smith, Vearch, Constable & Co., London.
22. Postgraduate Reproductive endocrinology. 4th Edition. 1997. R. Rajan Jaypee brothers. Medical Publishers (P) Ltd.
23. Practice of fertility control, Choudhary S. K. Churchill and Livingstone.
24. Progress in Reproductive Biology, Vol. 4. The pineal and reproduction : Reiter, R.J. Series Ed. P.O. Hubinant, Karger, Basel. Paris, London (latest edition).
25. Reproduction in Mammals Series : 1 to 6 : Austin, C.R. and R. V. Short (1984 & 1994),
Cambridge University Press, Cambridge.
26. Reproductive Endocrinology : Ref. No. 1, Vol. 3 Hormones in Reproduction.
27. Seasonal Patterns of Stress, immune function and disease R.J. Nelson, G.E. Demas, S.L. Klein, L.J. Kriegsfeld. 2002. Cambridge Univ. Press.
28. Shaw's textbook of Gynaecology eds. V. G. Padubidri and S. N. Daftary. 2000.
29. The Biology of Blastocyst : Blandau, R.J. (1971). The University of Chicago Press, Chicago & London.
30. The Prostaglandins Vol. I & II : Ramwell, P.W. (1974). Penum Press, New York and London.
31. The Testis Vol. 1 to 4 : Jhonson, A.D. and W. R., Gomes.
32. Vertebrate Foetal Membrances : Mossman, H.W. (1989). Rutgress Press Ltd.
33. WHO laboratory manual for the examination of human semen and sperm – cervical mucus interaction. 4th Edition Cambridge Univ. Press. 2000.

Semester –IV

Paper- XV, Special Group-Animal Physiology-III

Physiology of Brain, Nerve and Muscle

Unit-I

- 1.1 Morphological differentiation of mammalian brain
- 1.2 Brain stem
- 1.3 Cerebellum
- 1.4 Physiology of learning, memory and sleep

Unit-II

- 2.1 Types and functional properties of neurons
- 2.2 Ultrastructure of neuron
- 2.3 Ultrastructure of synapse and molecular mechanism of synaptic transmission
- 2.4 Bioelectrical properties of neurons- neuronal excitability, resting membrane potential- Nernst equation, sodium and potassium pump, propagation of nerve impulses, generation of action potential.

Unit III

- 3.1 Biosynthesis, storage and release of neurotransmitters : Acetylcholine , GABA, Epinephrine, Nor-epinephrine , Serotonin.
- 3.2 Neuropeptides- oxytocin, vasopressin, thyrotropin releasing hormone, cholecystokinin
- 3.3 Receptor physiology- Mechanoreception, photoreception, phonoreception, chemoreception
- 3.4 Disorders of nervous system: Alzheimer's disease, Parkinson's disease.

Unit-IV

- 4.1 Ultrastructure of skeletal muscle
- 4.2 Molecular mechanism of muscle contraction- muscle proteins, Calcium receptors, Calmodulin, Calcium pump, sliding filament theory, chemistry and role of ATP in muscle contraction.
- 4.3 Properties of muscle (twitch, tetanus, summation, tonus, all or none principle fatigue), muscular disorders.
- 4.4 Ultrastructure of Neuromuscular Junction.

Semester –IV

Paper XVI, Special Group-Animal Physiology-IV

Physiology of Respiration and Reproduction

Unit I

- 1.1 Physiological anatomy of respiratory system.
- 1.2 Mechanism of respiration – Mechanism of breathing and the exchange of respiratory gases at pulmonary surface.
- 1.3 Transport of respiratory gases by blood.
- 1.4 Lung volumes and capacities, partial pressure of gases.

Unit II

- 2.1 Oxygen dissociation curve, Carbon -dioxide dissociation curve.
- 2.2 Carbonic anhydrase, chloride shift.
- 2.3 Neural and chemical regulation of respiration
- 2.4 Hypoxia, Cyanosis.

Unit III

- 3.1 Testis- spermatogenesis , sperm capacitation.
- 3.2 Leydig cells, sertoli cells and their hormones
- 3.3 Ovary- mechanism of yolk synthesis, vitellogenesis
- 3.4 Corpus luteum- formation, structure , hormones and functions

Unit IV

- 4.1 Placenta - structure , hormones and functions
- 4.2 Physiology of lactation
- 4.3 Role of hormones and pheromones in reproduction
- 4.4 Causes of infertility in male and female; In vitro fertilization (IVF) and Test Tube Baby

Semester-IV, Practical-VII, Special Group- Animal Physiology

1. Physiology Experiments

- 1) Study of Electrocardiograph (ECG) under different physiological conditions.
- 2) Body size and oxygen consumption in aquatic animals.
- 3) Effect of pH, temperature on oxygen and carbon dioxide concentration in pond water.
- 4) Effect of starvation on tissue cholesterol in breed animals.
- 5) Effect of thyroxin in amphibian metamorphosis.
- 6) Measuring of heart beat under different physiological condition.
- 7) Study of nerve cells and neurosecretary cells of cockroach.
- 8) Estimation of SGOT/SGPT from given biological sample and study of it at different conditions.

2. Quantitative Analysis

- 1) Muscle & Liver glycogen.
- 2) Determination of fructose in seminal vesicle / semen.
- 3) Muscle protein separation by TLC / Paper chromatography.
- 4) Determination of semen constituents.
- 5) Determination of Brain calcium.
- 6) Determination of Brain glucose.
- 7) Estimation of percentage quantity of lactose in milk in vertebrates.

3. Qualitative Analysis

- 1) Estimation of lactate dehydrogenase.
- 2) Estimation of protein, RNA, DNA, glucose.
- 3) Estimation of total gonadal (testis) cholesterol from rat/mice.
- 4) Histochemical localization of a dehydrogenase.
- 5) Histochemical localization of Carbohydrate.
- 6) Histochemical localization of Glycogen.
- 7) Histochemical localization of lipid.
- 8) Histochemical localization of protein.

4. Histological Study: Brain, Testis, Ovary, Thyroid, Adrenal, Corpus luteum in ovary, Leydig cells in testis, T.S. Muscle fiber, T. S. Spinal cord, Cerebellum & cerebrum, Nerve fiber, Lung

Distribution of Marks :	Marks
1. Physiology Experiment	15
2. Major quantitative analysis	15
3. Minor quantitative analysis	10
4. Qualitative analysis	10
5. Identification and comment on spots(1-5)	15
6. Practical Record	10
7. Viva-voce	05

	80
Internal Assessment	20

Total marks	100
• Project work	100
(80 marks project evaluation including viva + 20 marks Internal assessment)	

Semester –IV

Paper-XV, Special Group-Cell Biology-III

Molecular Cell Biology

Unit-I

- 1.1 Prebiological chemical evolution and proto cells.
- 1.2 Cellular membranes – Molecular structure, transportation, protein channels and carriers, receptors, membrane potential.
- 1.3 Cytoskeleton – Microtubules & microfilaments – Structure and dynamics. Microfilaments membrane binding proteins and their function.
- 1.4 Cell-cell interactions and adhesion. Adhesion molecules involved. Cell-matrix interactions and adhesions. Adhesion molecules involved. Proteins of extracellular matrix. Types of junctions.

Unit-II

- 2.1 Protein structure – Primary, secondary, tertiary and quaternary, Domains and motifs, Protein folding, Ramchandran plot.
- 2.2 Molecular chaperons and heat shock proteins. Prion structure and functions.
- 2.3 Protein synthesis in eukaryotes. Up take into ER, Modifications in ER, Protein sorting in Golgi apparatus, Transport of proteins across nuclear membrane. Lysosomal assembly and functions.
- 2.4 DNA binding proteins – Leucine zipper, zinc finger, helix turn helix, beta barrel and OB fold.

Unit-III

- 3.1 Origin, epidemiology, causes and types of cancer.
- 3.2 Cytogenetical properties of normal and abnormal cells.
- 3.3 Proto-oncogenes and viral oncogenes, Mechanism of oncogene activation.
- 3.4 Tumor markers and tumor suppressor genes.

Unit-IV

- 4.1 Model organisms for molecular studies –Importance of *Drosophila melanogaster*, *C. elegans*, *S. cerevisiae*, zebra fish studies.
- 4.2 Cell senescence and apoptosis.
- 4.3 Somatic cell hybridization and chromosome mapping, Cell fusion and applications.
- 4.4 Protein and tissue engineering.

Semester –IV

Paper-XVI, Special Group-Cell Biology-IV

Applied Biotechnology

Unit-I

- 1.1 Marker assisted improvement of crop. Genetically modified food and future implications.
- 1.2 DNA and ribosomes as drug targets–Recent developments in drug delivery System, Ion channels as drug target, Drug metabolism.
- 1.3 Nanobiotechnology – Molecular motors, DNA hybridization control using ion Crystal antennae.
- 1.4 Bio-safety and bioethical considerations on biotechnology, biological warfare.

Unit-II

- 2.1 Biology, cause, diagnosis and treatment of influenza and hepatitis.
- 2.2 Biology, cause, diagnosis and treatment of Parkinson's disease.
- 2.3 Biology, cause, diagnosis and treatment of diabetes.
- 2.4 Biology, cause, diagnosis and treatment of cystic fibrosis.

Unit-III

- 3.1 Properties of stem cells. Types of stem cells – Embryonic, umbilical, adult.
- 3.2 Haemopoietic stem cells and formation of blood cells. Bone marrow transplantations.
- 3.3 Stem cell disorders. Stem cell therapy, Stem cell and cancer, Stem cell research in India.
- 3.4 Stem cells and tissue engineering, ethical, legal and social implications (ELSI) of Stem cell technology.

Unit-IV

- 4.1. World Trade Organization and trade related intellectual property rights (TRIPS).
- 4.2. Intellectual property rights – Patents and patent documentation.
- 4.3. Patent search methods & tools for patent search.
- 4.4. Indian patent laws and recent amendments, examples of patents in India & abroad.

Semester –IV Practical-VII, Special Group-Cell Biology

1. Measurement of maximal absorption of colored solutions and verification of Beer's Law.
2. Biochemical estimation of alkaline phosphatase.
3. Biochemical estimation of acid phosphatase.
4. Biochemical estimation of blood cholesterol.
5. Isolation of lymphocytes using Ficoll gradient.
6. Separation of amino acids from biological sample.
7. Electrophoretic separation of proteins.
8. Demonstration of Baculovirus.

9. Immunoelectrophoresis.
10. Countercurrent Immunoelectrophoresis.
11. Demonstration of primary cell culture.
12. Demonstration of tools used for patent search & patent filing system.
13. Preparation of neem extract as antimicrobial agent.
14. Visit to Central institute of Cotton Research, Intellectual Property Rights Training Institute.

Distribution of marks	Marks
1. Biochemical estimation of alkaline/acid phosphatase/ Cholesterol.	20
2. Electrophoretic separation of proteins/ separation of Amino acids.	20
3. Immunoelectrophoresis/ Countercurrent Immunoelectrophoresis/ Isolation of lymphocytes.	15
4. Verification of Beer's law/ Demonstration of baculovirus.	10
5. Class record/submissions.	10
6. Viva-voce.	05

	80
Internal Assessment	20

Total marks	100
• Project work	100
(80 marks project evaluation including viva + 20 marks Internal assessment)	

• **Suggested Readings**

1. The cell theory, QAMS: Vol. 89,96,1948-55,Bakar.
2. Synthetic activity of polythene chromosomes: Berendes (Int. Rev. Cytol. vol. 35, 1973)
3. The Nucleolus in the cell Metabolism: Bimstiel, Ann. Rev. Plant Physical vol.11 1967.
4. Elements of cytology: Cohen.
5. The nucleic Acid: Chargaff & Davidson.
6. The Bio-chemistry of DNA: Davidson.
7. Cell Biology- De Reoberts.
8. The cell-Biology: Dowbwn Haper.
9. Cell Biology: C. B. Powar.
10. DNA & Chromosomes, D.Praw.
11. Mitochondria structure & function: Ernster & Drahota.
12. Nuclear Envelope: Franke.
13. The structure of cell membrane: Fox.
14. Energy& Mitochondria: Green & H Baum.
15. Biological membrane: structure & function: Harrison & Lunt.

16. Studies in basic Genetics & Molecular Biology: Hayes & Wiley.
17. Cell Biology: Johan Paul.
18. The Mitochondria: Loghinger.
19. Hand book of Molecular Cytology: Lirna-de-Paria.
20. Cell structure & function: Loewy& Siskevit P.
21. Structure & function of biological membranes: Roth Field.
22. Molecular Genetics: Stent.
23. Cytogenetic: SwansonJ, Yount Yodyrdan Metz & W.J.
24. The molecular basic of membrane function: Yodyrdan.
25. Molecular Biology of Gene: W. Son.
26. The Chromosomes: White.
27. The Nuclear Envelope, Its ultra structure & functional Significance: Wisctinitzers, S.
28. Tissue Culture methods & Application: Kruse, P. F. Jr. Academic Press, M. KS
Patterson, New York, San Francisco, London, 1973.
29. Tissue culture technique:2nd Ed. Cameron G. Academic press, N. Y.
30. Laboratory Techniques in Biology & Medicine, Earle W.R
31. An Introduction to cell and tissue culture: Free, W. F. Burgess, Minneapolis.
32. Genes VI: Lwein, Benjamin(1997), Oxford University press, New York
33. Genetics: 3rd Ed., Stansfield W.D.(1991), Schaum's outline series, McGraw Hill Inc. New
York.
34. Genetics in Medicine: Thompson M. W., Mcinnes RR& HF. Willard (1991),W.
D. Saunders Co. Philadelphia.
35. A first course in Recombinant DNA Technology: Micklos D.A & G.A Freyer
(1990), Cold Spring Harbor Lab. Press.
36. Scientific American Books: Watson, J.D., Gilman, M. Witnowski,I.& M. Zoller
(1992), Distributed by W. H. Freeman & Co., New York.
37. Genetics, Weaver: RF. & P.W. Hedrick,(1989), Wnc Brown Publishers, Dubuque,
TOWA (USA).
38. Gene Regulation: A Eukaryotic Perspective, Latchrnan, Davin (1990), Un win
Hyman, London.
39. Gene Cloning: Brown.
40. Biotechnolgy: Higgins.
41. Essentials of Cytology: C.B. Powar (1996), Himalaya Pub. House, Bombay.
42. Cell Biology: David E. Sadava (1993), Jones & Bartlett Pub. Boston (London).
43. Biotechnology: Current Progress, Paul, N. Cherernisenoff & L.M. Ferrante (1991), A
technomic Pub. Co., Lancaster, U.S.A
44. Microbial Genetics, David Freifelder (1987), NAROSA Pub. House, (India).
45. Molecular Biology: David Freifelder (1987), NAROSA Pub. House, Delhi, India
46. Molecular Cell Biology, Lodish *et. al.*, (2007), W.H. Freeman and Company, New York,
USA.
47. Molecular Biology of the cell, Alberts *et. al.*, (2008), Graceland Science, Taylor &
Francis Group, New York, USA.
48. Cell Physiology Source Book: A Molecular approach, Sperelakis, (2001), Academic
Press, New York, USA.
49. Principles of Genome Analysis and Genomics, Primrose, S.B. and Twyman R.M., (7th
Ed., 2006), Blackwell Publishing Company, Malden, USA
50. Genomes 3, Brown, T. A., Garland Science Publishing, London, UK.
51. Bioinformatics: sequence and Genome Analysis, Mount, D.W., Cold Spring

Semester –IV

Paper XV, Special Group-Fresh water Zoology-III

Aquatic Biology

Unit-I

- 3.1 Plankton : Definition and classification. Diurnal and vertical movement of plankton.
- 3.2 Collection and preservation of plankton. Qualitative and quantitative study, importance of plankton .
- 3.3 Periphyton : Definition and composition, Types & Qualitative study of Periphyton
- 3.4 Quantitative study of Periphyton & its importance.

Unit-II

- 4.1 Nekton : Definition and composition, Study of various forms of nekton from aquatic ecosystem.
- 4.2 Bottom material : Sedimentations, Sediments in lakes and rivers.
- 4.3 Benthos : Definition and collection of benthos. Qualitative and quantitative study.
- 4.4 Importance of benthic organisms with reference to water quality and aquatic pollution.

Unit-III

- 1.1 Definition of Aquatic pollution, types & sources of pollutants.
- 1.2 Heavy metal and pesticide residues from agriculture fields & control measures.
- 1.3 Pollution processes in aquatic ecosystem: dispersion, degradation, accumulation, biomagnificance, transformation, movement and recycling.
- 1.4 Eutrophication

Unit-IV

- 2.1 Methods of assessment of pollutional status.
- 2.2 Biological indicators of pollution.
- 2.3 Drinking water treatment and Disposal of sewage.
- 2.4 Aquatic toxicology: Toxicants, toxicity concentration response relation and Bioassay study

Semester –IV

Paper XVI, Special Group-Fresh water Zoology-IV

Inland Fisheries

Unit-I

- 1.1 Inland fisheries resources - riverine, reservoir and lacustrine fisheries.
- 1.2 Fresh water fish culture and management techniques.
- 1.3 Basic experimental designs useful in aquaculture
- 1.4 Population dynamics of fish and stock assessment models.

Unit-II

- 2.1 Induced breeding of fish by hypophysation technique.
- 2.2 Bundh breeding of fish and use of natural & synthetic hormones in breeding.
- 2.3 Glass jar hatchery and Chinese hatchery systems for seed production
- 2.4 Nutritional requirement of carps and supplementary feeding.

Unit-III

- 3.1 Culture of air breathing fish and cage culture.
- 3.2 Mixed farming of fishes and culture of giant fresh water prawn.
- 3.3 Integrated fish farming with agriculture and live stock.
- 3.4 Culture of fresh water mussel for pearls.

Unit-IV

- 4.1 Fisheries extension and Co-operative societies.
- 4.2 Biochemical composition and economic importance of fishes.
- 4.3 Fish spoilage & preservation methods, and HACCP in processing industry.
- 4.4 Time series analysis and its significance.

Semester-IV, Practical-VII, Special Group- Fresh water Zoology

- 1) Qualitative and quantitative analysis of zooplankton.
- 2) Collection and analysis (qualitative and quantitative) of periphyton.
- 3) Collection and estimation (qualitative and quantitative) of benthos.
- 4) Detection of LC₅₀ value of toxicant to aquatic organism.
- 5) Determination of oxygen consumption of fish.
- 6) Permanent slide preparation of zooplankton.
- 7) Feed formulation by square method.
- 8) Estimation of Maximum sustainable yield (MSY) using surplus production model.
- 9) Dissection of pituitary gland / Weberian ossicles, and preparation of pituitary extract.
- 10) Identification of aquatic weeds, insects and weed fishes.
- 11) Aerobic plate count and Gram staining of bacteria
- 12) Estimation of protein by Folin – Lowry method.
- 13) Determination of acid value or free fatty acids (FFAs) in fish oil.
- 14) Identification of egg, spawn, fry & fingerlings of carps.
- 15) Visit to a fish farm for studying the culture and breeding activities.

Distribution of marks	Marks
1) Quantitative estimation of zooplankton or benthos / Oxygen consumption rate	10
2) Comment on ecological setup / Camera lucida drawing.	10
3) Preparation of artificial feed / Estimation of MSY / Estimation of protein	10
4) Determination of acid value/ Aerobic plate count / Gram staining of bacteria	05
5) Identification of spots (1 to10)	20
6) Dissection of pituitary gland / Weberian ossicles / Permanent mounting of zooplankton	10
7) Practical record and submission of slides	10
8) Viva – voce	05

	80
Internal Assessment	20

Total marks	100
• Project work	100

(80 marks project evaluation including viva + 20 marks Internal assessment)

• **Suggested Readings**

1. A textbook of fishery science and Indian fisheries- S. B. L. Srivastava
2. Fish and fisheries – Kamleshwar Pandey and J. P Shukala
3. A textbook of fish biology and fisheries – S.S. Khanna and H. R. Singh
4. A text book of fish biology and Indian fisheries- R.P. Parihar
5. General and Applied Ichthyology- S.K.Gupta and P.C.Gupta
6. An introduction to fishes- S. S. Khanna.
7. Fish processing technology – T. K. Govindon.
8. Hand book of breeding of major carps by pituitary hormones – S. L. Chonder.
9. Aquaculture – T. V. R. Pillay.
10. Diseases of cultivable freshwater fishes and their control – N. M. Chokraborty.
11. Fish and fisheries in India - V. G. Jhingran.
12. Indian fishes (Identification of Indian Teleosts) – T. A. Qureshi.
13. Introduction to tropical fish assessment per share, Erik Ursine and Siberian C. Verma.
14. Fish population dynamics – M. Devaraj.

Semester –IV

Paper XV, Special Group-Aquaculture-III

Aquaculture and Management

Unit-I

- 1.1 Preparation of pond: Liming and manuring.
- 1.2 Prestocking management of Nursery, Rearing and stocking ponds.
- 1.3 Control of aquatic weeds, predatory fishes, weed fishes and insects.
- 1.4 Post stocking management – stocking density, carrying capacity, enhancement of carrying capacity.

Unit-II

- 2.1 Nutritional requirements of culturable carps. Supplementary feeding. Artificial feed. Use of growth promoting hormones.
- 2.2 Transport of live fish seed, Brood fish and food fish.
- 2.3 Effect of dams on fisheries.
- 2.4 Development of reservoir fisheries in India.

Unit-III

- 3.1 Different systems of aquaculture, Monosex culture, cage culture and pen culture.
- 3.2 Polyculture of Indian and Exotic carps.
- 3.3 Culture of air breathing fishes.
- 3.4 Integrated aquaculture: fish-cum-poultry and fish-cum-paddy.

Unit-IV

- 4.1 Integrated fish farming: fish-cum-duck and fish-cum-pig
- 4.2 Sewage fed fish culture.
- 4.3 Cold water fish culture in India.
- 4.4 Extensive, Intensive, Semi-intensive and super- intensive culture.

Semester-IV

Paper XVI, Special Group-Aquaculture-IV

Fish Pathology and Fish Genetics

Unit-I

- 1.1 Biochemical composition of raw fish.
- 1.2 Nutritional value of raw and preserved fish.
- 1.3 Fish preservation objective and principles..
- 1.4 Methods of fish preservation.

Unit-II

- 2.1 Fish decomposition, rigor mortis and fish spoilage.
- 2.2 Poisoning, Toxicity and allergies from fish as food.
- 2.3 Effect of water pollution on fishes.
- 2.4 Fish products and byproducts.

Unit-III

- 3.1 Fungal, bacterial, protozoan diseases of farm fish.
- 3.2 Nutritional diseases of fish.
- 3.3 Worm and crustacean diseases of farm fish.
- 3.4 Diseases caused by aquatic pollutants.

Unit-IV

- 4.1 Fish genetic resources and its application in fisheries management.
- 4.2 Hybridization, transgenic fish.
- 4.3 Gene banking and application of genetic engineering in aquaculture.
- 4.4 Cryopreservation of gametes.

Semester –IV Practical-VII, Special Group- Aquaculture

- 1) Study of feeding habits of herbivorous, carnivorous and omnivorous fish by gut content analysis.
- 2) Identification of egg, spawn, fry and fingerlings of Indian carps.
- 3) Preparation of artificial fish feed.
- 4) Dissection of reproductive system of carps.
- 5) Identification and classification of palaemonoid prawns, crabs, bivalves, larvivorous and aquarium fishes.
- 6) Short term bioassay and determination of LC₅₀ for fish exposed to pollutant. .
- 7) Study of pathological changes in gills, liver, kidney and intestine of fish exposed to heavy metals or pesticides.
- 8) Biochemical estimation of proteins, lipids, glycogen, DNA and cholesterol.
- 9) Preparation of bacteriological media and determination of bacterial plate count for skin and gut .
- 10) Gram staining of bacteria.
- 11) Visit to a fish market and collection of fish landing data.

Distribution of marks	Marks
1) Analysis of gut content / preparation of artificial fish feed	10
2) Study of pathological changes in gills, liver, kidney and intestine	10
3) Biochemical estimation / determination of bacterial plate count.	10
4) Gram staining	05
5) Identification of spots (1 to10)	20
6) Dissection / Permanent mounting	10
7) Practical record & submission	10
8) Viva – voce	05

	80
Internal Assessment	20

Total marks	100

- **Project work** 100
(80 marks project evaluation including viva + 20 marks Internal assessment)

- **Suggested Readings**

1. A textbook of fishery science and Indian fisheries- S. B. L. Srivastava
2. Fish and fisheries – Kamleshwar Pandey and J. P Shukala
3. A textbook of fish biology and fisheries – S.S. Khanna and H. R. Singh
4. A text book of fish biology and Indian fisheries- R.P. Parihar
5. General and Applied Ichthyology- S.K.Gupta and P.C.Gupta
6. An introduction to fishes- S. S. Khanna.
7. Fish processing technology – T. K. Govindon.
8. Hand book of breeding of major carps by pituitary hormones – S. L. Chonder.
9. Aquaculture – T. V. R. Pillay.
10. Diseases of cultivable freshwater fishes and their control – N. M. Chokraborty.
11. Fish and fisheries in India - V. G. Jhingran.
12. Indian fishes (Identification of Indian Teleosts) – T. A. Qureshi.
13. Introduction to tropical fish assessment per share, Erik Ursine and Siberian C. Verma.
14. Fish population dynamics – M. Devaraj.

Semester –IV

Paper-XV, Special Group-Environmental Biology-III

Environmental Pollution and Aquaculture

Unit-I

- 1.1 Pollution Ecology: definition, sources of pollution, classification of pollutants, primary and secondary pollutants.
- 1.2 Air pollution: definition, sources, air pollutants and its effects on human health and atmosphere, control of air pollution.
- 1.3 Water Pollution: definition and sources, water pollutants and its effects, control of water pollution.
- 1.4 Noise pollution, sources, physiological and psychological effects of noise pollution, control measures of noise pollution.

Unit-II

- 2.1 Land pollution: definition, sources, effects and control of insecticide pollution.
- 2.2 Radioactive pollution: definition, sources, effects and control measures of radioactive pollution.
- 2.3 Biomedical waste: sources, effects and control measures
- 2.4 Hazardous waste: definition, sources, effects.

Unit-III

- 3.1 Biological and general effects of pollutants on organism.
- 3.2 Bioassay studies: definition, purpose, methodology, calculation of LC50 value, significance.
- 3.3 Bioaccumulation and biomagnifications.
- 3.4 Biotransformation of xenobiotics.

Unit-IV

- 4.1 Aquaculture: basic concept of fisheries, marine, inland and brackish water fisheries.
- 4.2 Indian major carps and their culture: fish, seed resources, transport.
- 4.3 Planning and management of freshwater fish farm.
- 4.4 Fishery economics and management: role of fishery co-operative societies, economics of fishery, aquaculture and rural development.

Semester –IV

Paper-XVI, Special Group-Environmental Biology-IV

Man and Environment

Unit-I

- 1.1 Natural resources: definition, concept, types of natural resources, use and abuse of natural resources.
- 1.2 Wild life: wild life in India, endangered species of mammals, birds, amphibian and reptiles,
- 1.3 Causes of wild life depletion, necessity of wild life conservation.
- 1.4 Modes of conservation, national parks and sanctuaries, strategies for biodiversity conservation, gene pool.

Unit-II

- 2.1 National resources: minerals, nutrient cycles, exploitation of nutrient resources.
- 2.2 Biomass, biogas and solar energy.
- 2.3 Conservation and sustainable development of natural resources, bacteria and biodegradation
- 2.4 Biodiversity- definition, types, hotspots of biodiversity.

Unit-III

- 3.1 Conservation of natural resources: potable water criteria, water supply, water borne diseases and control measures, bioremediation of ponds and lakes.
- 3.2 Process of soil formation, composition, soil profile, soil erosion, methods of conservation of soil.
- 3.3 Conservation of forest: needs, afforestation, deforestation, agroforestry, forest conservation through law.
- 3.4 Social forestry and environment.

Unit-IV

- 4.1 Environmental policy, social economic and legal aspects, social forestry, enforcement of anti pollution law.
- 4.2 Environmental education: environmental education programmes, environmental education in India
- 4.3 Formal environmental education, stages of environmental education, non formal environmental education.
- 4.4 Environmental Organizations and agencies.

Semester-III, Practical-VII, Special Group-Environmental Biology

1. Bioassay test- toxicity evaluation of heavy metals/pesticides using snail/fish as test animals, determination of LC₅₀ value.
2. Determination of oxygen consumption in normal fish/snail at different temperature.
3. Alteration in the oxygen consumption of fish / snail exposed to pollutants (heavy metals / pesticides).
4. Estimation and proximate composition (Protein / glycogen) in normal and treated fish / snail.
5. Determination of NO₂ and SO₂ in ambient air.
6. Determination of suspended particulate matters in ambient air.
7. Determination of oil and grease by Soxhlet apparatus and separating funnel.
8. Identification of common commercial important inland / marine fishes, Crustaceans and mollusc.
9. Identification of maturity stages in fish.
10. Determination of gonadosomatic index.
11. Study of fecundity of fish.
12. Physicochemical analysis of Soil, pH, moisture.
13. Field work and study tour:
 - a) Visit to National Institute / Centre of Aquaculture.
 - b) Visit to a fish farm
 - c) Visit to National park / sanctuary to observed wildlife and maintaining the field diary.
 - d) Study tour and visit to national Institute of Oceanography.

Distribution of Marks

	Marks
1. Major experiment	15
2. Minor experiment	10
3. Minor experiment	10
4. Identification and comments on given spots (1-10)	30
5. Class record	10
6. Viva voce	05

	80
Internal Assessment	20

Total marks	100

- **Project work** 100
(80 marks project evaluation including viva + 20 marks Internal assessment)

● Suggested Readings

1. The Science of Ecology: Brewer, A. (1998), Sanders Pub. New York.
2. The Science of Ecology: Ehrlich, P. R. & Rousharden, J. (1987) McMillan Pub. Co. New York.
3. Population Biology: Emlein, J. M. (1984). McMillan Pub. London.
4. Current Ecology: Pattern & Progress: Killawa, J. & Anderson, G.J. (1986), Blackwell Science Publication, Oxford.
5. Basic Ecology: Odum, E. P. (1983), Sanders Pub. New York.
6. Systems of Ecology: Odum, H. T. (1983), John Wiley & Sons, New York.
7. Ecology with Special Reference to Animals and Man: Kendelgh, Prentice Hall Co.
8. National Resources & Conservation: Owen, O. S. (1985) McMillan Pub. New York.
9. Elements of Ecology: Smith, R. L. (1986), Harper & Row Pub. New York.
10. Environmental Physiology: Sonim, N. B. (1974), C. V. Mosby Pub. St. Louis, USA.
11. Environmental Physiology: Philips, J. G. (1975), Blackwell Science Publication, Oxford.
12. Ecology: Ricklefs, R. E. (1973), Thomas Nelson & Sons Ltd.
13. Threatened Animals of India: Tikader, B. K. ZSI Calcutta.
14. Ecology & Field Biology: Smith, R. L. Harper & Row Pub. New York.
15. Wildlife in India: Sharin, V. B. (1985), Natraj Pub. Dehradun.
16. Fresh Water in India: Kulkarni, K. H. (1957), ICAR, New Delhi.
17. Marine Fishes: Bal, D. V. & Rao, K.V. (1989), Tata McGraw Hill, New York.
18. Textbook of Marine Ecology: Balkrishnan, N. A. & Thumphy, D. N. (1980), McMillan Co.
19. Marine Ecology & Fishes: Cushly, B. H. (1980), Cambridge University Press.
20. Treatise on Limnology: Hutchinson, G.E., (1967), John Willy Pub. New York.
21. Methods of Soil Analysis: De, S. K. (1962), Narayan Pub. House, Allahabad.
22. Fish & Fishes of India: Jhingran, V. G. (1985)
23. **Aquatic Pollution:** Edward A. (2000) Laws. 3rd edition. **John Wiley and Sons**, New York.
24. A Manual of Fresh Water Ecology: Santhanam, R., Velayntan, P. & Jagathesan, G. (1989), Daya Pub. House, Delhi.
25. Limnology: Welch, P. S. (1957), McGrall & Hill Co. New York.
26. **Air Pollution:** Perkins, H.C., (1974) McGraw-Hill, New York.

Semester-IV

Paper-XV, Special Group-Sericulture-III

Silkworm Genetics, Breeding and Seed Technology

Unit-I

- 1.1 Hereditary traits of egg, larva, cocoon, pupa and adult, characters and effect of environment on them.
- 1.2 Genetics of cocoon colours, linkage maps and inheritance of cocoon colour, environment influence and hormone control.
- 1.3 Inheritance of voltinism, moultnism, environment influence and hormone control.
- 1.4 Sex Determination in *B. mori* : Sex determination, sex linked, sex limited traits and their special significance in sericulture.

Unit-II

- 2.1 Breeding of Silkworm: Pre-requisites, aims and objectives, variability in breeds.
- 2.2 Methods of Breeding: Line breeding, cross breeding and mutation breeding, tropical and temperate races.
- 2.3 Silkworm breeding in India - its problems, advantages and disadvantages.
- 2.4 Heterosis, utilization of heterosis in sericulture.

Unit II

- 3.1 Selection, preservation and incubation of seed cocoons.
- 3.2 Grainage and basic equipments.
- 3.3 Management of grainage.
- 3.4 Silkworm Egg Production : Moth emergence, mating, egg laying (DFLs) and mother moth examination.

Unit-III

- 4.1 Disinfection and preservation of eggs.
- 4.2 Transportation and maintenance of eggs.
- 4.3 Artificial hatching (Acid treatment) of uni and biovoltine eggs.
- 4.4 Embryonic development, inhibition of embryonic development.

Semester-IV

Paper-XVI, Special Group-Sericulture-IV

Rearing of silkworm and Silk Technology

Unit-I

- 1.1 Silkworm rearing, principles of silkworm rearing.
- 1.2 Types of rearing houses.
- 1.3 Rearing equipments.
- 1.4 Disinfection of rearing house and appliances.

Unit-II

- 2.1 Rearing Methods: Early age rearing (chowki rearing) and late age rearing.
- 2.2 Environmental conditions for silkworm rearing, Precautions for rearing.
- 2.3 Mounting, spinning and harvesting of cocoons.
- 2.4 Cocoon sorting, transportation of cocoons.

Unit-III

- 3.1 Grading of cocoons, stifling/ drying, storage and preservation of cocoon, deflossing.
- 3.2 Boiling of Cocoon: Appliances, methods of boiling and processing of cocoon for reeling.
- 3.3 Reeling appliances and methods of reeling.
- 3.4 Silk Reeling Operations: Re-reeling, silk testing and skeining of silk yarn, preparation and preservation of silk yarn, Process of winding, process of doubling, process of twisting, stifling of twisted yarn, process of reeling.

Unit-IV

- 4.1 Silk weaving, bleaching and dyeing of twisted yarn.
- 4.2 Warping unit and process of warping. Bobbin filling machine and process of filling, weaving machine, process of weaving, testing and storage of silk fabric.
- 4.3 Marketing of Silk: Indian market, international market, foreign exchange earning.
- 4.4 Silk industry in various states of India, role of silk industry in Indian economy.

Semester-III, Practical VI-Special Group- Sericulture

1. Characterization of silkworm breeds/ races.
2. Cytological technique – Temporary preparation of slide:
 - i) Determination of somatic chromosome number of mulberry.
 - ii) Mitotic and meiotic chromosomes - preparation of the root tip, and
 - iii) Slide preparation of chromosomes of silkworm.
3. Study of rearing appliances and rearing of silkworm (100 dfls).
4. Disinfection - Type of sprayers and methods of their use.
5. Emergence of moths, selection of moths, pairing and de-pairing, oviposition, preservation of male moth.
6. DFL preparation (Card and Loose eggs) Cold and hot acid treatment methods.
7. Embryo mounting - preparation and mounting of different embryonic stages of silkworm.
8. Rearing of silkworm and harvesting of cocoons.
9. Determination of good and defective cocoons and their percentage based on appearance and weight.
10. Determination of shell ratio, percentage and estimation of renditta.
11. Single cocoon reeling - Determination of average filament length and denier (size).
12. Reeling technique - Single cocoon reeling (Approuvet), charka reeling, cottage basin, filature (multi end).
13. Field work and study tour - Study tour and visit to sericulture centers.

Distribution of Marks:

	Marks
1. Identification and comment on the spots (1-5)	15
2. Demonstration of meiotic and mitotic chromosomes in Mulberry plant	10
3. Demonstration of reeling and production of yarn	10
4. Determination of shell ratio, percentage and estimation of renditta	10
5. Determination of average filament length and denier	10
6. Mounting of embryonic stages of silkworm	10
7. Practical record	10
8. Viva voce	05

80

Internal Assessment

20

Total marks

100

- **Project work** 100
(80 marks project evaluation including viva + 20 marks Internal assessment)

- **Suggested Readings**

1. Handbook of Practical Sericulture : Ullal, S.R. and Narasimhanna, M.N. (1987), Central Silk Board Publication, Bangalore.
2. Text Book of Tropical Sericulture : (1975), Publ., Japan Overseas Corporation

- Volunteers.
3. FAO Manual on Sericulture : Anonymous (1972), Vol. I - IV.
 4. An Introduction to Sericulture : Ganga, G. and Chetty S.J. (1997), 2nd Edition, Oxford and IBH Publishing Co. Ltd., New Delhi.
 5. Principles of Sericulture : Hisao Aruga, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
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Question paper pattern: Guidelines to paper setters

The theory question papers comprises of **four** questions. All questions are compulsory and carry equal marks.

Question No. 1 to 4

- Q. 1. One long answer question from Unit-I
or
Two short answer questions/notes from Unit-I
- Q. 2. One long answer question from Unit-II
or
Two short answer questions/notes from Unit-II
- Q. 3. One long answer question from Unit-III
or
Two short answer questions/notes from Unit-III
- Q. 4. One long answer question from Unit-IV
or
Two short answer questions/notes from Unit-IV