

GONDWANA UNIVERSITY, GADCHIROLI



BOARD OF STUDIES IN ZOOLOGY

**SUBMISSION OF
CHOICE BASED CREDIT SYSTEM
SYLLABUS FOR POST GRADUATE (M. Sc.) PROGRAMME
FROM SESSION 2016 - 17**

Gondwana University, Gadchiroli

Scheme and syllabus under choice based credit system.

Syllabus for M. Sc. Zoology (Semester with choice based credit system) w e f 2016-17
Academic Session.

Scheme of teaching and examination under semester pattern Choice Based Credit System
(CBCS) for M.Sc. Program in Zoology

M. Sc. Zoology Semester I

Code	Theory / Practical	Teaching scheme (Hours / Week)				Credits	Examination Scheme				
		Th	Pract	Total	Duration in		Max. Marks		Total Marks	Minimum Passing Marks	
							er n al	ie m al		Th	Prac
Core 1	Paper 1: Structure and Function of Invertebrates	4	-	4	4	3	80	20	100	40	
Core 2	Paper 2: General Physiology	4	-	4	4	3	80	20	100	40	
Core 3	Paper 3: Cell Biology and Genetics	4	-	4	4	3	80	20	100	40	
Core 4	Paper 4: Advanced Reproductive Biology	4	-	4	4	3	80	20	100	40	
Pract. Core 1 & 2	Practical Based on theory Paper 1 & 2	-	8	8	4	3-8*	80	20	100		40
Pract. Core 3 & 4	Practical Based on theory Paper 3 & 4	-	8	8	4	3-8*	80	20	100		40
Seminar 1	Seminar 1	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		480	125	625	170	80

M. Sc. Zoology Semester II

Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Duration in	Examination Scheme				
		Th	Pract	Total			Max. Marks		Total Marks	Minimum Passing Marks	
							Th	Pract		Th	Pract
Core 5	Paper 5: Structure and Function of Vertebrates	4	-	4	4	3	80	20	100	40	
Core 6	Paper 6: Comparative Endocrinology	4	-	4	4	3	80	20	100	40	
Core 7	Paper 7: Molecular Biology and Biotechnology	4	-	4	4	3	80	20	100	40	
Core 8	Paper 8: Advanced Developmental Biology	4	-	4	4	3	80	20	100	40	
Pract. Core 5 & 6	Practical 3: Based on theory Paper 5 & 6	-	8	8	4	3-8*	80	20	100		40
Pract. Core 7 & 8	Practical 4: Based on theory Paper 7 & 8	-	8	8	4	3-8*	80	20	100		40
Seminar 2	Seminar 2	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		480	145	625	170	80

Gondwana University, Gadchiroli
Changes in practical curriculum as per UGC Notification No. F.14-6/2014
(CPP-II) Dated 1st August 2014
(w.e.f. academic session 2016-17)
Important Instructions

- I. Use of animals for dissection for practical purpose in the curriculum is banned by UGC vide its notification No. F.14-6/2014 (CPP-II) dated 1st August 2014. It is now essential to use necessary alternatives to stop dissection and promote and orient students towards the knowledge component rather than skill development using ICT and available resources without disturbing natural habitat. To understand anatomy of any animal, virtual dissection of the animal should be conducted through various computer simulations. These digital learning devices and available resources are to be used to demonstrate the dissection of the animals and other laboratory exercises and to evaluate the students at the time of examination and to ensure compliance of the aforesaid notification.
- II. Those institutions which are already having Zoology museum / Permanent Slides / Skeleton and Loose Bones of any animals should use them till they last. No new specimens/ slides or any other laboratory material procured from animal source shall be purchased for conducting practicals mentioned here- in above. If needed, they should purchase charts/ models/ photographs or digital sources as alternatives.
- III. During regular practical and practical examination, for anatomical observations, demonstration and detailed explanation of the given system of Invertebrate/ Vertebrate animal, the student will expose/ explain the given system of the animal and draw, label and comment on it.
- IV. During regular practical and practical examination, for mounting of given material and permanent stained preparation, the student is expected to describe the process and/or identify, draw, label and describe the given material.

Semester-I

(CREDIT - 4)

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 organelles, flagella, cilia and pellicularmyonemes) and mechanism of various modes of locomotion.
- 1.3 Dermal cells and skeletal organization in calcareous sponges, Hexactinilida and Demospongiae (Porifera).
- 1.4 Polymorphism and metagenesis in coelenterate. Types of polyps, medusa and metamorphosis.

Unit-II

- 2.1 Origin of metazoan-colonial, syncytial and molecular theories.
- 2.2 Reproductive system-structure and mechanism of reproduction in *Dugesia*, *Fasciola*, *Taenia* and *Ascaris*.
- 2.3 Formation, Evolution and significance of coelom, metamerism and symmetry in classification of animals, particularly coelomata.
- 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

(CREDIT - 4)

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 transamination 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

(CREDIT - 4)

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, coefficient 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, Advanced Reproductive Biology

(CREDIT - 4)

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 (CREDIT - 4) Section-A

- 1 Study of museum specimens using already available specimens in the museum/ charts/ models/ photographs/ digital alternatives etc.**
Classification upto order and comments on the specimens representing all phyla.
- 2 Anatomical Observations**
Anatomical observations, demonstration and detailed explanation of a) **Digestive system** of Earthworm, Leech, Cockroach, Silkworm and Honey bee b) **Nervous system** of Prawn, Cockroach, Silkworm and Honey bee and c) **Reproductive system** of Earthworm, Leech, Cockroach and Honey bee with the help of ICT tools/ Models/ Charts/ Photographs etc.
- 3 Mounting-** Whole mount preparation of plankton and/or study of permanent preparation of the following with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
 - a. Earthworm – Nerve ring, ovary, spermatheca, nephridia.
 - b. Leech – jaws, ciliated organ.
 - c. Cockroach – Mouth parts, Salivary glands, trachea.
 - d. Prawn – Appendages, Statocyst.
 - e. Protozoans- rhizopods , flagellates , ciliates (fresh water forms).
 - f. Porifera – Spicules and gemmules of fresh water sponges.

- g. Crustaceans and rotifers - Planktonic copepodes, cladoceran, ostracoderm and rotifers.
- h. Larval forms of the free living invertebrates.
- i. Larval forms of parasitic invertebrates.

4 Study of permanent Invertebrate slides

- a. Porifera – T.S. and L.S. of *Sycon*, gemmules, spongianfibres, spicules
- b. Coelenterata – T.S. of *Hydra*, T.S. of Sea anaemon, Ephyra larva
- c. 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 *Ancylostoma*, *Enterbios*, *Dracunculus*, *Wuchereria*
- d. Annelida -T.S. of *Nereis*, T.S. of Earthworm, T. S. of Leech.
- e. Arthropod larvae – Nauplius, Zoa, Metazoa, Megalopa, Mysis.
- f. Mollusca – T.S. of foot, Veliger and Glochidium larva.
- g. Echinodermata- pedicellarae, T.S. of arm of star fish, Bipinnaria, Auricularia larva.
- h. Hemichordata – T.S. through collar, proboscis, trunk and branchio-genital regions. Tornaria larva.

Section-B

Physiology experiments –

- a. Total leucocyte count and differential leucocyte count.
- b. Total R.B.C. count.
- c. Demonstration of action of salivary amylase, trypsin, pepsin.
- d. 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 (Source of blood: Local recognized pathology laboratory).
- g. Estimation of glucose in blood by spectrophotometer or Colorimeter (Source of blood: Local recognized pathology laboratory).
- h. Estimation of total blood proteins by spectrophotometer or Colorimeter (Source of blood: Local recognized pathology laboratory).
- i. Estimation of cholesterol in blood by spectrophotometer or Colorimeter (Source of blood: Local recognized pathology laboratory).

Distribution of Marks:

	Marks
1. Anatomical observations	05
2. Stained permanent preparation:	05
3. Identification and comment on the spots (1-10)	20

4.	Physiology experiment (Major)	15
5.	Physiology experiment (Minor)	10
6.	Submission of stained permanent slides	05
7.	Class Record	10
8.	Viva-voce	10

Total marks 80

**Semester-I, Practical-II, Cell Biology, Genetics and Advanced Reproductive Biology
(CREDIT - 4)**

Section-A

1. Study of mitotic metaphasic chromosomes in plant material.
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 with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
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 with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 2 Demonstration of oogenesis in earthworm/ fish/ rat ovary with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
- 3 Semen analysis: physical viscosity, pH, liquefaction time, agglutination test, motility and sperm count (Source of semen: Government artificial insemination centre).
- 4 Sperm vitality study using suitable stains (Source of semen: Government artificial insemination centre).
- 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) with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
- 7 Histology of male and female reproductive organs and accessory reproductive glands with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.

Distribution of Marks

	Marks
1. Cytological preparation	15
2. Problems on genetics (any two)	15
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	10

	Total marks	80

• **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 McLennan , 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 Upadhyay A and Upadhyay 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. 4thEdn. 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

(CREDIT - 4)

Unit-I

- 1.1 Origin and ancestry of Chordata.
- 1.2 General organization and affinities of Cephalochordata.
- 1.3 Structure, development and metamorphosis of Amocoetus.
- 1.4 General characters and affinities of Dipnoi.

Unit-II

- 2.1 Organs and mechanism of respiration in Pisces and Amphibia.
- 2.2 Vertebrate integument and its derivatives.
- 2.3 Appendicular skeleton (Limbs and girdles) in Amphibia, Reptilia, Aves and Mammals.
- 2.4 General body organization and classification in Chelonia.

Unit-III

- 3.1 Evolution of urinogenital organs in vertebrates.
- 3.2 Origin of Birds.
- 3.3 Cetacea: general characters and adaptations.
- 3.4 Comparative anatomy of the brain in vertebrates (teleost, frog, lizard, fowl and rat).

Unit- IV

- 4.1 Autonomous nervous system in vertebrates: structure and functions.
- 4.2 Evolution of heart in vertebrates.
- 4.3 Sense organs in vertebrates.
- 4.4 Evolution of Man.

Semester-II

Paper-VI, Comparative Endocrinology

(CREDIT - 4)

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 Hypothalamo hypophysial system: structure, hypothalamic nuclei, hormones and function.
- 3.3 Pituitary: cell types, hormones and functions.
- 3.4 Thyroid: Structure, hormones and function.

Unit-IV

- 4.1 Parathyroid 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

(CREDIT - 4)

Unit-I

- 1.1 Cot $\frac{1}{2}$ and Rot $\frac{1}{2}$ values, organelle genome, 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.
- 1.4 Mismatch repair, recombination repair, double strand break repair, and transcription coupled repair.

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, Advanced Developmental Biology

(CREDIT - 4)

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 (CREDIT - 4)

Section-A

- 1 **Study of museum specimens using already available specimens in the museum/ charts/ models/ photographs/ digital alternatives etc.**

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

- 2 **Anatomical Observations**

Anatomical observations, demonstration and detailed explanation of the following with the help of ICT tools/ models/ charts/ photographs etc.

a) Brain and cranial nerves- Fish/ Rat. b) Arterial and venous systems- Fish/Rat c) Urinogenital system- Fish/Rat. d) Reproductive systems- Fish/Rat. e) Internal ear in fish, Weberian ossicles in fish, accessory respiratory organs in fish.

- 3 **Mounting:** Study of Stained Permanent preparation of scales, ampullae of Lorenzini, otolith, striated muscles and cartilage of fish using animal wastes from local recognized fish markets or with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.

- 4 **Microtomy, Histology and Skeleton**

a. Fixation, embedding, sectioning and staining of the internal organs of vertebrates (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry farms/ fish markets etc.)

b. Study of slides of internal organs of vertebrates with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.

c. Axial and appendicular skeleton of fowl and rabbit using already available skeleton/ ICT tools/ models/ charts/ photographs etc.

Section-B

- 1 **Microtomy** - Fixation, embedding, sectioning and staining of the endocrine gland (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry farms/ fish markets etc.)

- 2 **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 with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.

- 3 **Anatomical Observations-** Anatomical observations, demonstration and detailed explanation of the endocrine glands in a) Cockroach and b) Endocrine glands- pituitary,

thyroid parathyroid, adrenal in fish/rat with the help of ICT tools/ models/ charts/ photographs etc.

Distribution of Marks	Marks
1. Anatomical observations of fish/rat	10
2. Stained permanent preparation:	05
3. Identification and comment on the spots (1-10)	20
4. Submission of stained permanent slides	05
5. Anatomical observations of Endocrine glands	10
6. Histological staining of endocrine gland	10
7. Class Record	10
8. Viva-voce	10

Total marks	80

**Semester-II, Practical –IV, Molecular Biology, Biotechnology and Developmental Biology
(CREDIT - 4)**

Section-A

1. Demonstration of glycogen/ carbohydrate- PAS reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
2. Demonstration of DNA: Feulgen's reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
3. Demonstration of DNA: RNA: Methyl Green- Pyronin reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
4. Demonstration of Lipid: Sudan Black B staining (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
5. Demonstration of Protein: HgBP staining (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
6. Histochemical analysis of alkaline phosphatase (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
7. Histochemical analysis of acid phosphatase (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
8. Biochemical estimation of sugar: O-toluidine method (Source of blood: Local recognized pathology laboratory)
9. Biochemical estimation of protein: Lowrey's method (Source of blood: Local recognized pathology laboratory)
10. Biochemical estimation of DNA: Diphenylamine method (Source of blood: Local recognized pathology laboratory)
11. Biochemical estimation of RNA: Orcinol method (Source of blood: Local recognized pathology laboratory)To perform tests for qualitative analysis of saliva
12. To perform tests for qualitative analysis of bile

13. Demonstration of separation of amino acids by paper chromatography and TLC

Section-B

- 1 Study of the reproductive system in mammals with the help of ICT tools/ models/ charts/ photographs etc.
- 2 Study of different types of eggs on the basis of their yolk content.
- 3 Study of developmental stages of live eggs of Lymnea or any gastropod with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 4 Study of developmental stages of insects/ fishes with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 5 Study of developmental stages of frog with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 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 with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 9 Histological study of placenta with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 10 Sperm count from any domestic animal (Source of semen: Government artificial insemination centre).

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)	10
6. Class record	10
7. Viva voce	10

Total marks	80

• **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, Outlines 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 phylogeny 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. Hardisty 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 Endocrinological: Bentley, 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.