

Jan Nayak Chandrashekhar Vishwavidyalaya, Ballia
M. Sc. Zoology Syllabus
(w.e.f. 2020-21)

M. Sc. Previous

I- Semester	Marks
I- Paper- Comparative study of Lower non-chordates	75
II- Paper- Biostatistics, Biosystematics and Bioinstrumentation	75
III- Paper- Environmental Biology and Bioinformatics	75
IV- Paper- Biochemistry	75
Practical	100
Total	400
II- Semester	
I- Paper- Comparative study of Higher non- chordates	75
II- Paper- Animal Physiology	75
III- Paper- Cytology and Genetics	75
IV- Paper- Molecular Biology	75
Practical	100
Total	400

M. Sc. Final

III- Semester

I- Paper- Comparative study Proto-chordates and Lower- vertebrates	75
II- Paper- Development Biology	75
III- Paper- Endocrinology	75
IV- Paper- Special	
Fish- Taxonomy and Morphology	75
Practical Examination- Part- A. (General)	50
Part- B. (Special)	50
Total	400

IV- Semester

I- Paper- Comparative study of Higher- Vertebrates	75
II- Paper- Animal Behavior	75
III- Paper- Special	75
Fish- Applied Ichthyology and Development	
IV- Paper- Special	75
Fish- Physiology and Ecology	
Practical- Part- A. (General)	50
Part- B. (Special)	50
Total	400

M. Sc. (Zoology)

I- Semester

Paper I- Comparative Study of Lower Non-chordates

Unit 1: Protozoa

- (i) Phylogeny of Invertebrates
- (ii) Osmoregulation- Contractile vacuoles and mechanism of osmoregulation,
- (iii) Locomotion- Locomotor organelles and methods of locomotion
- (iv) Nutrition- Holozoic, Holophytic, Saprozoic and Myxotrophic nutrition
- (v) Reproduction- Asexual and sexual
- (vi) Protozoa and Diseases

Unit 2: Porifera

- (i) Phylogenetic origin and evolution of Metazoa.
- (ii) Cellular Organization- Pinacoderm, Choanoderm, Mesenchyme
- (iii) Skeleton- Spicules and spongin
- (iv) Reproduction- Asexual and Sexual
- (v) Canal System- Types and functions of canal system

Unit 3: Coelenterata and Ctenophora

- (i) Polymorphism- Basic forms and patterns, Importance of polymorphism
- (ii) Colony formation; Metagenesis
- (iii) Corals- coral polyp, coral skeleton, types of corals
- (iv) General Organization and affinities of Ctenophora

Unit 4: Platyhelminthes and Aschelminthes

- (i) Parasitism in Platyhelminthes and Aschelminthes,
- (ii) Parasitic adaptations in Trematodes and Cestodes- Morphological and physiological adaptations
- (iii) Larval stages of Trematodes and Cestodes

(iv) General organization and affinities of Rotifers

Suggested Books: Invertebrates, Parker Haswell, Invertebrate Zoology, Ruppert, Invertebrates series- Protozoa – Echinodermata, R L Kotpal; Modern Textbook of Zoology- Invertebrates, R L Kotpal.; Invertebrate Zoology, N C Nair; A textbook of Invertebrates, H S Bhamrah; Non-chordates- E L Jordon

Paper II

Biostatistics, Biosystematics and Bioinstrumentation

Unit 1: Biostatistics

- (i) Major Tendencies (Mean, Median, Mode),
- (ii) Standard deviation/Standard error,
- (iii) Analysis of Variance: one way, two way and Manova

Unit 2: Biosystematics

- (i) Speciation- Dimensions and mechanism of speciation
- (ii) Species Concept- Species category and different species concept,
- (iii) Theories of Biological Classification.

Unit 3: Biological Techniques

- (i) Principles of Colorimetry and Spectrophotometry- Lambert Beer Law,
- (ii) Centrifugation- Principles and technique,
- (iii) Chromatography- Principles, types and applications
- (iv) Electrophoresis- Principles, agarose and polyacrylamide gel electrophoresis and applications, Western and Southern Blotting.

Unit 4: Microscopy

Principles and construction of-

- (i) Compound microscope
- (ii) Phase contrast microscope/ Fluorescence Microscope
- (iii) Electron microscope: SEM & TEM
- (iv) Confocal microscope

Suggested Books: Biostatistics, P Ramakrishnan; Biostatistics, B K Mahajan; Animal Taxonomy, V C Kapoor; By Ashok Verma, Alld. Principles of Animal Taxonomy, G G Simpson; Tools and Techniques in Biomolecular Science, Aysha Divan; Microscopy, Terence Allen; Principles and Techniques of Biochemistry and Molecular Biology, Wilson K and Walker J.

Paper III

Environmental Biology and Bioinformatics

Unit 1: Ecosystem

- (i) Nature of Ecosystem
- (ii) Production, Food webs and Energy flow through ecosystems
- (iii) Biogeochemical cycles
- (iv) Biomes

Unit 2: Population Ecology & Community

- (i) Characteristics of Population
- (ii) Population size and exponential growth
- (iii) Population dynamics; r and k selection.
- (iv) Ecological interactions (Mutualism, Protocooperation, Commensalism, Predation, Parasitism, Amensalism, Competition)
- (v) Community structure and its attributes; Levels of species diversity, edge and ecotone.

Unit 3: Environment

- (i) Environmental stresses: air, water, soil, microbial, noise and thermal pollutions
- (ii) Global warming & Climate change, Acid rain, Ozone layer depletion
- (iii) Environmental contaminants- their uptake and biotransformation
- (iv) Bio-indicators and Biomarkers, Environmental monitoring/auditing
- (v) Biodiversity- Assessment, conservation and management of biodiversity

Unit 4: Bioinformatics

- (i) Computer applications: MS-Office- Word, Excel, Power point presentation, precautions and safety measures.

(ii) Introduction and scope of Bioinformatics; Data archiving systems: FASTA format, Accession and GI-Number, Databases: NCBI, PDB, KEGG, and PubMed.

(iii) Concept of homology: BLAST, Clustal-W and their applications; Protein structural visualization tools.

Suggested Books: Fundamentals of Ecology, E P Odum; Ecology and Environment, P D Sharma; Environment and Ecology, R Rajgopalan; Ecology and environmental biology- K A Siddiqui; Bioinformatics and functional Genomics, Pevsner J; Essential Bioinformatics, Xiong J.

Paper IV

Biochemistry

Unit1: Bioenergetics

(i) Elementary thermodynamics- First law and second law of thermodynamics

(ii) Cell as an open thermodynamic system

(iii) Calculation of free energy change during biological oxidation-reduction reactions

Unit2: Enzymes

(i) Mechanism of enzyme action, Activation energy

(ii) Kinetics of enzyme action,

(iii) Enzyme inhibition- Competitive and non-competitive inhibitors, Lineweaver- Burk curve and its significance in prediction of type of inhibition,

(iv) Allosteric enzymes

Unit 3: Biomolecules & Metabolic Pathways

(i) Carbohydrates- Classification, structure, general properties and biological significance

(ii) Lipids- Classification, structure, general properties and biological significance

(iii) Proteins structure and function, Isoelectric point, Sequencing of proteins: Sanger and Edman methods

(vi) Metabolic pathways- Glycogenesis and Glycogenolysis, Gluconeogenesis, HMP shunt, Oxidative phosphorylation, Beta oxidation of fatty acids, Nucleotide metabolism.

Unit 4:

(i) Classification and significance of Vitamins,

(ii) Biology of Cancer- Neoplasia, Metastasis, Phases of cancer, Oncogenes and carcinogens

(iii) Biology of Ageing

Suggested Books: Biochemistry, Stryer; Principles of Biochemistry, Lehninger; Biochemistry, J L Jain;

Paper V

Practical Examination

Particulars	Marks
Major Dissection-	20
Preparation-	10
Spotting (10) -	20
Environmental Biology exercise-	10
Biochemistry exercise-	15
Biostatistics exercise-	10
Bioinformatics	05
Class record, collection and viva	10
TOTAL	100

Major Dissections: Dissection of circulatory system and reproductive system of earthworm, Digestive system and Reproductive system of leech and other available lower non-chordates.

Preparations: Slide preparation of Euglena and Paramecium, sponge gemmules, Obelia colony and other available materials from lower non-chordates.

Museum study: General survey and classification of lower non-chordates

Protozoa: Prepared slides of Paramecium (conjugation and binary fission), Euglena, Vorticella, Ceratium, Noctiluca.

Porifera: Museums of Euplectella, Spongilla, Euspongia Prepared slides of T.S. Sycon, L.S. Sycon, Spicules of sponges.

Coelenterata- Museums of Physalia, Corralium, Madrepora, Fungia, Pennatula, Metridium, Vellela,

Porpita, Tubipora, Gorgonia, Prepared slides of Hydra, Obelia,

Helminths- Museums of Taeniasolium, Cysticercus larva of Taeniasolium, Schistosoma, Ascaris male, Ascaris female, Ancylostoma,

Prepared slides- Miracidium larva, Redia larva, Cercaria larva, Scolex of Taeniasolium, Mature proglottid and gravid proglottid of T. solium, T.S of Mature proglottid and gravid proglottid of T. solium, T.S. through body of male Ascaris, T.S. through body of female Ascaris.

Environmental Biology exercise: Study of different structural adaptations to ecological conditions
Study of micro and macro fauna of soil by froth-floatation method

Comparative study of physico-chemical eco-factors in different localities: temperature, pH,

Estimation of CO₂, O₂, carbonate in freshwater,

Study of plankton in a water body

Study of biological effects of certain pollutants.

Biochemistry exercise: Chromatographic separation of amino acids

Isolation and colorimetric determination of glycogen in animal tissues.

Kinetic assay of salivary amylase and study of the effects of time and temperature on urease activity

Biostatistics exercise: Experiments on probability, probability, t-test, Chi square test

Sampling of data for frequency diagram and calculation of mean, median and mode and standard

Deviation, Anova.

Bioinformatics: Hands on Bioinformatics databases and tools

M. Sc. (Zoology)**II Semester****Paper I****Comparative Study of Higher Non-chordates**

Unit 1- Annelida: Segmental organs, Filter feeding, Adaptive radiation in Polychaetes, Coelom and Metamerism.

Unit 2- Arthropoda: Larval forms of Crustacea, Parasitism in Crustacea, Respiration in Arthropods, General characteristics, Organization and Affinities of Onychophora.

Unit 3- Mollusca: Respiration, Nervous system, Foot in Mollusca, and Torsion and detorsion in Gastropods.

Unit 4- Echinodermata: Water vascular system, Larval forms and Affinities.

Suggested Books: Invertebrates, Parker Haswell, Invertebrate Zoology by RD Barnes; Invertebrate Zoology, Ruppert, Invertebrates series- Protozoa – Echinodermata, R K Kotpal; Modern Textbook of Zoology- Invertebrates, R L Kotpal.; Invertebrate Zoology, N C Nair; A textbook of Invertebrates, H S Bhamrah

Paper II**Animal Physiology****Unit1-**

Physiology of Digestion: Digestion and Absorption of Proteins, Carbohydrates and lipids.

Physiology of Respiration: Gaseous exchange in terrestrial and aquatic animals, Respiratory pigments.

Unit 2

Physiology of Circulation: Patterns of Circulation among different animals, Physiological categories of Heart, Haemodynamics.

Physiology of Excretion: Excretory products, Biosynthesis of Urea, Structure and functional mechanism of nephron.

Concept of Homeostasis

Unit 3

Physiology of Nerve Conduction: Structure of neurons, Ionic basis of resting and Action potential, Synaptic transmission at molecular levels;

Physiology of Muscle Contraction: Structure of skeletal muscle, Mechanism of Muscle Contraction

Physiology of Reproduction: Male and female reproductive system of mammals

Sense organs: Stato-acoustic system, Touch receptor, Thermoreceptor

Unit 4- Physiology of Defense: Innate and adaptive immunity, Types of Immune response, cells and organs of immune system, Antigens and antibodies, their interaction, generation of antibody diversity. Complement system, MHC and antigen presentation, Cytokines, hypersensitivity reactions, tolerance and autoimmunity, Vaccines: active and passive immunization, and types of vaccines.

Suggested Books: Medical physiology, Guyton; Human physiology, C C Chatterjee; Animal physiology, Nagabhushanam, Physiology and Biochemistry, Srivastava and Agrawal; Immunology, Kuby.

Paper III Cytology and Genetics

Unit 1- A Brief introduction of Bacteriophages, Animal viruses, and Retroviruses, Structure of *E. coli*; Plasmids

Unit 2- Fluid mosaic model and functions of Plasma membrane, Membrane transport of small molecules, Energy transduction in mitochondria, Cell cycle and its control .Cell-cell communication

Unit 3- Mendel's laws and their chromosomal basis, Genetic interaction: dominance, epistasis, pleiotropy, expressivity and penetrance; Linkage and Crossing over, gene mapping, Sex-determination, Sex-linked inheritance, pedigree analysis and its application.

Unit 4-Human cytogenetics

Karyotype, Chromosomal aberrations, Mutation.

Population genetics: Allele and genotype frequency, Hardy-Weinberg Law, Genetic Drift, Epigenetics; Human genetic diseases

Suggested Books: Genetics, P K Gupta; Genetics, B D Singh; Genetics, P S Verma; The Cell: a Molecular Approach, Cooper; Molecular Biology of the Cell, Alberts; Genetics: A Conceptual Approach, Benjamin A. Pierce; Principles of Genetics: Snustad and Simmons; Genetics: a Molecular Approach by Peter J. Russell.

Paper IV
Molecular Biology

Unit 1- Gene Action

- (i) Chromosomal organization of genes, Eukaryotic gene structure, Non-coding genes, principal classes of DNA (A, B, and Z) DNA replication, Transcription, Genetic code, Giant chromosomes.
- (ii) Polymerase chain reaction and DNA Sequencing: Sanger Sequencing and Next Generation Sequencing

Unit 2-

- (i) Protein Architecture, Protein synthesis on free/bound polysomes.
- (ii) Uptake into ER, Trafficking mechanism of proteins; regulation of intracellular transport; Post-translational modification of proteins.
- (iii) Liposomes and drug targeting; DNA Fingerprinting.

Unit 3- Regulation of Gene Action

Regulation of Gene action in prokaryotes: Operon model- lac operon and Trp- operon; gene regulation in eukaryotes at transcriptional and post-transcriptional levels (Britten-Davidson model); silencers and enhancers.

Unit 4- Cell Signalling

Concept of cell signaling; Types of Cell Signaling: Paracrine, autocrine, endocrine, synaptic; Combinatorial signaling; Intracellular receptors; Cell surface receptors: Ion channel linked receptors, G-Protein linked receptor; Mechanism of signaling through G-Protein linked receptor; Enzyme linked receptors, Mechanism of action via enzyme linked receptor; Second messenger system, Mechanism of action of cyclic AMP; Apoptosis.

Suggested Books: Molecular biology of the gene, J D Watson; Molecular Biology, N Arumugam; Genes, Lewin. Principles of Genetics: Snustad and Simmons; Molecular Cell Biology, Lodish.

Paper V
Practical Examination

Particulars	Marks
Major Dissection-	20
Minor Dissection-	10
Preparation-	05
Spotting (10) -	20
Physiology exercise-	10
Molecular Biology exercise-	10
Cytology and Genetics exercise-	10
Class record and collection-	08
Comprehensive viva -	07
TOTAL	100

Major Dissection- Nervous system of Pila, Unio, Sepia, and other available materials of higher nonchordates

Minor Dissection- Nervous system of Prawn, Other minor dissections of available higher non-chordates

Preparation- Hastate plate of prawn, parapodia of Neries, Mouth parts and salivary glands of cockroach, Mouth parts of other insects, and of other available materials.

Museum and prepared slides study- General survey and classification of higher nonchordates

Annelida-Nereies, Heteroneries, Aphrodite, Chaetopterus, Arenicola, Terebella, Pheretima, Eutyphoeus, Dero, Branchellion, Bonellia, Sipunculus and other available museums T.S. Nereies through body segments, Parapodium of Nereies, etc.

Arthropoda- Museums and slides of major representatives of different classes of phylum Arthropoda

Mollusca- Museums and slides of major representatives of Mollusca

Echinodermata- Museums and slides of major representatives of Echinodermata.

Physiology exercise-

Total counts of erythrocytes, total leucocyte counts and differential leucocyte counts of fish, frog, bird and rat.

Estimation of hemoglobin content in fish, frog, bird and rat.

Rate of Oxygen consumption of aquatic animals and effects of different stresses upon it.

Determination of respiratory quotient of an air breathing animal

Study of functional properties of the cardiac muscles of frog using acetylcholine and adrenalin

Recordings of Electro cardiogram of frog.

Molecular Biology exercise-

Isolation and colorimetric determination of protein from fat bodies of cockroach and liver

Isolation and colorimetric determination of DNA from fat bodies of cockroach and liver. .

Cytology and Genetics exercise-

Demonstration of mitochondria in human buccal epithelium by supra vital staining

Study of mitosis in onion root tip and meiosis in testis of grasshopper with acetocarmine squash method

Study of salivary gland chromosomes of Drosophila and Chironomos

Study of the pattern of different hereditary traits in human beings, Karyotyping.

Gene Mapping exercise.

M.Sc. (ZOOLOGY) FINAL YEAR

III Semester

Paper I

**Comparative Study of Proto-chordates and Lower vertebrates
(Protochordates, Fish, Amphibia)**

Unit I

- (i) General organization and affinities of Protochordates
- (ii) Origin of Chordates
- (iii) Origin of Tetrapods

Unit II

- (i) Integument in fish and Amphibia.
- (ii) General plan of digestive system in fish and Amphibia
- (iii) General plan of circulation in fish and Amphibia

Unit III

- (i) Respiratory system in fish and Amphibia
- (ii) Skeletal system in fish and Amphibia
- (iii) Evolution and organization of Urinogenital system in fish and Amphibia

Unit IV

- (i) Nervous system in fish and Amphibia
- (ii) Sense organs in fish and Amphibia.
- (iii) Lateral line system in fish

Suggested Books: Vertebrate Zoology, G R Beer, Comparative anatomy of vertebrates, R K Saxena, Vertebrates, R L Kotpal, Vertebrates, P S Verma; Chordates- E L Jordon; Zoology, Miller & Harley; Life of vertebrate, JZ Young.

Paper II

Developmental Biology

Unit 1. Gonads and Gametogenesis

- (i) Sex differentiation in vertebrates
- (ii) Comparative account of differentiation of gonads in mammals,
- (iii) Spermatogenesis in vertebrates
- (iv) Endocrinology of Ovary, Oogenesis and Vitellogenesis in vertebrates, Superovulation.
- (v) Hormones and Reproduction- Seasonal and Continuous breeders

Unit2. Fertilization and Embryogenesis

- (i) Fertilization: in vivo and in vitro, recognition of gametes and acrosomal reaction, prevention of polyspermy and gamete fusion, activation of egg metabolism.
- (ii) Patterns of Cleavage
- (iii) Patterns of Gastrulation in frog and chick: fate maps, cell movement and formation of germ layers.

Unit3. Organogenesis

- (i) Origin of anterior-posterior and dorsal-ventral polarity in *Drosophila*
- (ii) Axis formation in amphibians: Nieuwkoop centre and primary Organizer
- (iii) Axis formation in birds.
- (iv) Development of Brain in Amphibia.
- (V) Development of Eye in Amphibia.

Unit 4

- (i) Specification, determination and differentiation of cells during embryonic development
- (ii) Mechanism of Induction during Organogenesis, Primary organizer
- (iii) Development of limb in vertebrates: Involvement of Homeobox genes.
- (v) Regeneration and embryonic stem cells, its scope and applications

Suggested Books: Chordate embryology, P S Verma; Developmental Biology, S Gilbert, Developmental Biology, Subramaniam, An Introduction to Embryology, Boris Belinsky,

Paper III

Endocrinology

Unit 1

- (i) Hormones: Characteristics and types,
- (ii) Neuroendocrine system: Hypothalamo-hypophyseal system; Neurosecretion
- (iii) Structure and endocrinology of Pituitary

Unit 2

- (i) Phylogeny, structure and functioning of Thyroid.
- (ii) Endocrinology of Parathyroid and Calcium regulation in body
- (iii) Structure and endocrinology of Pancreas

Unit 3

- (i). Structure and hormones of Adrenal.
- (ii) Endocrinology of Gonads and Placenta. Reproductive cycle, gestation & Parturition
- (iii) Hormones and their functions of Pineal gland and Kidney

Unit 4

- (i) Nature of action of peptide and steroid hormones
- (ii) Feedback mechanisms
- (iii) Biosynthesis and secretion of Hormones: apocrine, holocrine, and paracrine)

Suggested Books: Endocrinology, Turner and Bugnara; Endocrinology, Hadley; Endocrinology, K V Shastry; Williams Textbook of Endocrinology, Melmed et al.

Paper IV
Special Paper: Fishery Biology
Taxonomy & Morphology

Unit 1. Taxonomy

- (i) Classification of fish up to orders as proposed by **L. S. Berg** (1940) , **Greenwood** (1966) and **Pough et al.** (1989)
- (ii) Systematic/Taxonomic study of freshwater and marine fish of following orders
1. Order- Clupeiformes. Families- Clupeidae (including oil sardine), Notopteroidae.
 2. Order- Beloniformes. Families– Belonidae Hemiramphidae
 3. Order- Mastacembeliformes. Family- Mastacembelidae.
 4. Order- Mugiliformes. Family- Mugilidae
 5. Order- Perciformes, Family- Scombridae (Mackerel)
 6. Order- Scopeliformes, Family- Harpodontidae (Herpodon)

Unit 2. Identification of Fish

Study and preparation of identification key of the fish of following orders with suitable diagrams, fin formula, local and biological names,

1. Ophiocephaliformes 2- Cypriniformes 3- Perciformes

Unit 3

- (i) Study of differentiating characters of pair of fish from the orders of Fresh water fish given in to (Ophiocephaliformes, Cypriniformes, Perciformes) with special reference to fin formula, suitable diagrams, local and biological names.
- (ii) Scales in fish, Fins and their origin.
- (iii) Tails in fishes

Unit 4. Morphology

- (i) Specialized organs (electric organs, poison glands, sound producing organs, light producing organs, the lateral line system, and Weberian ossicles)
- (iii) Endocrine glands (Pineal, hypophysis, thyroid, adrenal, ultimobranchial body, corpuscles of Stannous, urophysis, liver, and kidney).

Suggested Books: Fishes of UP and Bihar, Gopalji Srivastava; An Introduction to Fishes, S S Khanna, Ichthyology, Lagler; Inland Fishes, P K Talwar; A Handbook Of Fish Biology & Indian Fisheries, Parihar R P; Text Book of Ichthyology, Pandey K C & Agrawal N.

Paper V
PRACTICAL EXAMINATION

PART A: GENERAL

Major Dissection-	10
Minor Dissection-	05
Microtomy-	05
Developmental biology-	05
Endocrinology-	05
Spotting (05)-	10
Class record, collection and viva	10
Total-	50

Major Dissection- Dissection of cranial nerves of major representative types of fish and amphibian. Neck nerves of a mammal Afferent and efferent branchial arteries of Scoliodon

Minor Dissection- Eye muscles of Scoliodon, internal ear, urinogenital system of Scoliodon,

Preparation- Placoid scales of Scoliodon, Ampulla of Lorenzini; T.S. through liver, intestine, skin etc. offrog, Microtomy of tissues

Museum study- Study of museums and slides of representative types of Protochordates, Cyclostomata, Fish and Amphibia

Developmental Biology- Study of life stages of frog, mounting of eggs and embryo of frog, incubation and mounting of chick embryo, study of prepared slides of embryo of frog, chick and mammal, window formation.

Endocrinology- Study of prepared slides of different endocrine glands of fish and frog, dissection of vertebrate types to demonstrate different endocrine organs,

PART B
SPECIAL PAPER
Fishery Biology

Major Dissection-	10
Preparation-	05
Identification of two fish-	10
Spotting (05)-	10
Seminar-	05
Class record, collection and Viva-	10
Total -	50

Major Dissection- Cranial nerves of Wallago, Labeo and Scoliodon; Afferent and efferent branchial vessels of Scoliodon, Wallago, Eye muscles of Scoliodon and Wallago,

Preparation- Preparation of Placoid scales, Cycloid scales and Ctenoid scales

Identification- Identification of freshwater fishes of U.P and Bihar with the help of Identification key.

Study of specimens, slides and bones of fishes- Specimens of both freshwater and marine water fishes

Seminar- Seminar presentation for 15 minutes compulsory for each student

Fish collection- Collection of at least ten different types of fish available in local habitats

M.Sc. (ZOOLOGY) FINAL YEAR
IV Semester
Paper I
Comparative Study of Higher vertebrates
(Reptiles, Birds and Mammals)

Unit 1. Reptiles and Birds

- (i) Origin and evolution of Reptiles,
- (ii) Extinct reptiles,
- (iii) Origin of Birds,
- (iv) Flightless birds

Unit 2. Mammals

- (i) Origin of Mammals,
- (ii) Structural peculiarities and phylogenetic relations of Prototheria and Metatheria,
- (iii) Dentition in mammals,
- (iv) Aquatic mammals

Unit 3. Circulation and Respiration

- (i) General plan of circulation in reptiles, birds and mammals
- (ii) General plan of respiration in reptiles, birds and mammals

Unit 4. Urinogenital and Skeletal system

- (i) General plan of urino-genital system in reptiles, birds and Mammals
- (ii) Skeletal system in reptiles, birds and Mammals.

Suggested Books: Vertebrate Zoology, G R Beer, Evolution of the Vertebrates, Colbert *et al.*; Comparative anatomy of vertebrates, R K Saxena, The life of vertebrate, Young J Z; Vertebrates, R L Kotpal, Vertebrates, P S Verma, Birds, R L Kotpal; Chordates- E L Jordon

Paper II

Animal Behaviour

Unit 1. Learning and Communication

- (i) Innate and Learning behavior; Memory
- (ii) Communication (chemical, visual, audio) among animals
- (iii) Biological clocks: Circadian, Lunar and Annual Rhythms
- (iv) Physiology and molecular biology of Biological Rhythms

Unit 2. Reproductive Behaviour

- (i) Courtship and mating behavior;
- (ii) Mating systems: Polyandry and Polygyny
- (iii) Sexual selection, pre-copulatory & post copulatory,
- (iv) Last male precedence, Sperm competition & cryptic female choice

Unit 3. Migration and Parental care

- (i) Migration in fish
- (ii) Migration in birds
- (iii) Parental care in fish
- (iv) Parental care in amphibians

Unit 4. Orientation and Social Behaviour

- (i) Orientation in animals,
- (ii) Altruism and evolution- Group selection, Kin selection, Reciprocal altruism
- (ii) Social behavior in insects and mammals, Eusociality

Suggested Books: Animal Behaviour, V K Agrawal ; Text book of Animal behavior, F B Mandal ;

Animal behavior, H S Gundevia; Animal Behaviour, S Prasad; Animal Behaviour: An Evolutionary Approach, Alcock J; Animal Behaviour, Manning and Dawkins.

Special Papers**Fishery Biology****Paper III****Applied Ichthyology and Development****Unit 1**

- (i) Fisheries of India; Brief study of Marine, fresh water, estuarine and cold water fishery.
- (ii) Fish Farming: Type of fish farming, fish ponds, construction of fish ponds, physico-chemical and biological characteristics of ponds, fishing methods.
- (iii) Fertilization and management of fishery pond (spawning, hatching, rearing, stocking); transport and mortality of fish fry.
- (iv) Composite culture and cage culture; integrated fish farming

Unit 2

- (i) Principle and importance of fish preservation; traditional and advanced methods of fish preservation: sun-drying, salting, pickling, smoking, chilling, frying and canning etc.
- (ii) Fish products (Fish oil, Fish sauce, Fish Glue etc.) and their importance.

Unit 3

- (i) Application of genetics in aquaculture: sex manipulation, chromosomal manipulation, gene engineering.
- (ii) Transgenic fish.
- (iii) Production of mono-sex and sterile fish and their Significance in aquaculture.
- (iv) Induced breeding

Unit 4 Development and Growth:

- (i) Cleavage and Gastrulation.
- (ii) Neurulation.
- (iii) Organ formation.
- (iv) Larval development.
- (v) Metamorphosis.
- (vi) Growth and age,

Suggested Books: General and Applied Ichthyology, S K Gupta; Applied Ichthyology, G S Sandhu,

Paper IV
Fish Physiology and Ecology

Unit 1

1. Nutrition- Alimentary canal, associated glands, food and feeding habits, digestion.
2. Excretion - Kidney structure and modifications, nitrogenous and excretory products, urine formation.
3. Osmoregulation- Definition, osmoregulation in freshwater, marine and migratory fishes.

Unit 2

4. Respiration- Structure and function of gills, process of respiration in a typical fish, accessory respiratory organs.
5. Circulatory System - Heart structure and function, fish blood and blood vessels, arterial and venous system.

Unit 3

6. Fish nervous system
7. Reproduction- Gonads structure, spermatogenesis, oogenesis, gonadal steroids, endocrine control of reproduction, and fertilization.
8. Common enemies and symptoms, etiology and treatment of disease of food fishes.

Unit 4 Ecology:

- (i) Abiotic factors: density, pressure, temperature, salt content in water, light, sound, electric currents, bottom deposits, particles suspended in water.
- (iii) Biotic factors: inter-specific interactions among fishes and with other organisms; intra-specific interactions among fishes.
- (iv) Pollutants affecting fishery water with special reference to oil spills, domestic pollutants, industrial water, radioactive wastes and sewage fed fisheries. Effects of pesticides and heavy metals on fishes; bioaccumulation and bio-magnification; dose response relationship and toxicity curve, LC50.
- (v) Plankton in relation to fish production.
- (vi) Larvivorous Fish

Suggested Books: Physiology of Fishes, David Evans; Anatomy and physiology of fishes, S Kumar; Freshwater fishes and their ecology, Stephen Forbes; Fish and fisheries- Pandey and Sukla.

Paper V**PRACTICAL EXAMINATION****A. GENERAL**

Dissection major	10
Dissection minor	05
Preparation	05
Animal Behaviour Exercise	05
Spotting (5)	10
Class record and collection-	08
Viva-voce -	07
Total-	50

B. SPECIAL (Fishery Biology)

Dissection major-	10
Dissection minor-	05
Preparation-	05
Ecology exercise-	05
Seminar	05
Spotting-(5)	10
Class record, collection and viva-voce-	10
Total-	50

Major Dissection: Digestive system, Urinogenital system, Cranial nerves of Wallago, and Scoliodon.

Minor Dissection: Scroll valve of Wallago and Scoliodon, Accessory respiratory organs of Heteropneustes fossilis, Weberian ossicles,

Preparation: Scales of fish, internal ear

Ecology Exercise-

Ecological adaptation in fishes

Preparation of fish feed

Study of pond ecology: measurement of pH, hardness, transparency, dissolved oxygen, dissolved CO₂,
Qualitative study of plankton

Seminar presentation for 15 minutes by every student.

Study of Specimens, slides and bones of fishes belonging to different orders

Collection-Collection of fishes available in local habitats; Collection of skull bones of Labeo and Wallago.