JIWAJI UNIVERSITY, GWALIOR

MASTER OF SCIENCE

ZOOOLOGY

2014 - 2016

The course for Master of Science (M.Sc.) in Zoology shall comprise of four semesters of six months duration each. Each semester shall include four theory papers and two practical (laboratory) courses. Each theory course will be of 85 marks each and there shall be a related internal assessment for each theory course involving 15 marks. Each practical course will include 100 marks each. The practical examinations may be held before or after theory examinations.

The students are required to participate in study excursions of short and/or long-term duration organized by the School as and when possible.

The students have to select one of the following specializations (electives) that shall be taught in third and fourth semesters:

A. Aquatic Biology & Aquaculture
B. Cell Biology
C. Endocrinology
D. Entomology
E. Fish Biology and Fisheries

M.Sc. in Zoology: Course codes and titles
<table>
<thead>
<tr>
<th>First semester</th>
<th>Second semester</th>
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<tr>
<td>ZOOL. 101: Structure &amp; Function of Invertebrates</td>
<td>ZOOL. 201: General &amp; Comparative Animal Physiology</td>
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<tr>
<td>ZOOL. 102: Biostatistics, Bioinformatics &amp; Research Methodology</td>
<td>ZOOL. 202: Biomolecules: Structure and function</td>
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<tr>
<td>ZOOL. 103: Cellular and Molecular Biology</td>
<td>ZOOL. 203: Population Ecology &amp; Environmental Biology</td>
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<tr>
<td>ZOOL. 104: Tools &amp; Techniques for Biology</td>
<td>ZOOL. 204: Biosystematics, Taxonomy &amp; Evolution</td>
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<tr>
<td>ZOOL. 105: Invertebrates, Quantitative Biology &amp; Bioinformatics (Practical)</td>
<td>ZOOL. 205: Physiology &amp; Biochemistry (Practical)</td>
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<tr>
<td>ZOOL. 106: Molecular Cell Biology, Genetics &amp; Tools &amp; Techniques (Practical)</td>
<td>ZOOL. 206: Ecology, Environmental Physiology, Systematics, Taxonomy &amp; Evolution (Practical)</td>
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<tr>
<td><strong>Third semester</strong></td>
<td><strong>Fourth semester</strong></td>
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<tr>
<td>ZOOL. 301: Comparative Anatomy of Vertebrates</td>
<td>ZOOL. 401: Animal Behaviour</td>
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<td>ZOOL. 302: Developmental Biology</td>
<td>ZOOL. 402: Biology of Parasitism &amp; Vertebrate Immune System</td>
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<tr>
<td>ZOOL. 303 (A): Aquatic Ecology &amp; Resources</td>
<td>ZOOL. 403 (A): Fisheries &amp; Pisciculture</td>
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<tr>
<td>ZOOL. 303 (B): Methods in Cell &amp; Molecular Biology</td>
<td>ZOOL. 403 (B): Neurobiology &amp; Aging</td>
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<tr>
<td>ZOOL. 303 (C): Comparative Endocrinology</td>
<td>ZOOL. 403 (C): Male Reproductive Endocrinology</td>
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<tr>
<td>ZOOL. 303 (D): General Entomology &amp; Insect Morphology</td>
<td>ZOOL. 403 (D): Insect Taxonomy, Ecology &amp; Development</td>
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<tr>
<td>ZOOL. 303 (E): Fish Structure &amp; Function</td>
<td>ZOOL. 403 (E): Taxonomy, Systematics &amp; Ecology of Fishes</td>
</tr>
<tr>
<td>ZOOL. 304 (A): Fish Biology &amp; Physiology</td>
<td>ZOOL. 404: (A): Aquaculture ZOOL. 404 (B): Chromosomes, Genes &amp; Genetic Engineering</td>
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<tr>
<td>ZOOL. 304 (B): Cellular Structure &amp; Molecular Organization</td>
<td>ZOOL. 404 (C): Female Reproductive Endocrinology</td>
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<td>ZOOL. 304 (C): Endocrine Physiology</td>
<td>ZOOL. 404 (D): Applied Entomology</td>
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<tr>
<td>ZOOL. 304 (D): Insect Anatomy &amp; Physiology</td>
<td>ZOOL. 404 (E): Pisciculture &amp; Economic Importance of Fishes</td>
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<tr>
<td>ZOOL. 303 (E): Fish Morphology &amp; Anatomy</td>
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<tr>
<td>ZOOL. 305: Vertebrates &amp; Genes &amp; Differentiation (Practical)</td>
<td>ZOOL. 405: Animal Behaviour, Biology of Parasitism &amp; Vertebrate Immune System (Practical)</td>
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<tr>
<td>ZOOL. 306 (A): Aquatic Biology &amp; Fish Biology (Practical)</td>
<td>ZOOL. 406: (A): Fisheries, Pisciculture &amp; Aquaculture (Practical)</td>
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<tr>
<td>ZOOL. 306 (B): Cell Biology (Practical)</td>
<td>ZOOL. 406 (B): Cell Biology (Practical)</td>
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<tr>
<td>ZOOL. 306 (C): General &amp; Comparative Endocrinology &amp; Endocrine Physiology (Practical)</td>
<td>ZOOL. 406 (C): Reproductive Endocrinology (Practical)</td>
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<tr>
<td>ZOOL. 306 (E): Fish Biology (Practical)</td>
<td>ZOOL. 406 (E): Fish Biology &amp; Fisheries (Practical)</td>
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**DETAILED SYLLABUS**

**FIRST SEMESTER:**
**ZOOLOG. 101: STRUCTURE AND FUNCTION OF INVERTEBRATES**

**UNIT I**
1. Organization of coelom: Acoelomates, Pseudocoelomates and coelomates
2. Protostomia and Dueterosstomia
3. Locomotion: Flagellar and ciliary movement in Protozoa
4. Hydrostatic movement in Coelenterata, Annelida and Echinodermata

**UNIT II**
5. Patterns of feeding and digestion in lower Metazoa
6. Filter feeding in Polychaeta, Mollusca and Echinodermata
7. Organs of respiration: Gills, lungs and trachea
8. Respiratory pigments and their functions
9. Mechanism of respiration and transport of gases

**UNIT III**
10. Organs of excretion: Coelom, coelomoducts, nephridia and Malphigian tubules
11. Mechanism of excretion in invertebrates
12. Primitive Nervous system of Coelenterates and Echinoderms
13. Advanced Nervous system of Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda)

**UNIT IV**
14. Trends in neural evolution
15. Larval forms of crustacean, mollusca and echinodermata
16. Larval forms of invertebrate parasites
17. Strategies and evolutionary significance of larval forms

**UNIT V**
18. Organization and general characters of Rotifera
19. Organization and general characters of Acanthocephala
20. Organization and general characters of Ectoprocta
21. Organization and general characters of Endoprocta

**Suggested Readings:**
Sedgwick, A.A. *Student Text Book of Zoo*
ZOOL. 102: BIOSTATISTICS, BIOINFORMATICS & RESEARCH METHODOLOGY

UNIT I

1. The mean, mode, median, Standard deviation and Standard error of classified Data
2. Distribution: Normal, Binomial and Poisson
3. Hypothesis testing: Chi Square test, f -Test
4. Student’s t test

UNIT II

5. Analysis of variance(one way and two way ANOVA)
6. Correlation & Regression
7. Sampling: Methods & significance
8. Tabulation & Presentation of data

UNIT III

9. Computers and their applications in biology
10. Operating systems: DOS, WINDOWS
11. Application softwares: MS Word, MS Access, MS Excel, MS Power Point
12. Internet and its uses

UNIT IV

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

UNIT V

17. Research: Definition and meaning of research problem
18. Research design
19. Research methodology
20. Interpretation of research outcome and writing report

Suggested Readings:
Pielou, E.C. The Interpretation of Ecological Data: A Primer on Classification and Ordination.
De Sapio, Calculus for Biologists.
Rubinov, S.I. Introduction to Mathematical Biology.
Saxena, V.P. ‘Jaiv Ganit Ek Parichaya’ (M.P. Hindi Granth Academy).
Swindell. Internet for the Molecular Biologists III. Horizon Scientific, 1996.
Rastogi S. C. et. al., Bioinformatics, Methods & applications. PHI Learning Pvt. Ltd., New Delhi

ZOOL. 103: CELLULAR AND MOLECULAR BIOLOGY

UNIT I

1. Biomembranes: Structure of Membrane (Fluid mosaic model), Molecular composition of the membrane, functional significance
2. Transport across cell membranes: Simple diffusion and osmosis, facilitated diffusion (Transporters, uniports and antiports carriers, symports, Ion channels), Active transport, Membrane pumps, Bulk transport (Endocytosis and Exocytosis)
4. intracellular transport: Axonal transport, Transport of pigment is melanophores: Role of kinesin and dynein

UNIT II

6. Cell junctions (occluding, Anchoring & Gap junctions)
7. Signal transduction mechanisms: Basic concept
8. Apoptosis: Basic concept

UNIT III

9. Neurons: General organization of neurons, Classification of neurons
10. Glia: Structure & Types of glia, Functions of glia
11. Synapses: Ultrastructure of a synapse, Types of synapses, Synaptic transmission: Electrical & chemical, Functions of nerve fibers
12. Muscle contraction: Excitation – contraction coupling and Sarcoplasmic reticulum

UNIT IV
14. Organelle genome: Structure and functions of Mitochondrial genome
15. Gene mutation: Induced and spontaneous mutations
16. DNA damage and repair: Types of DNA damage, Basic pathway of DNA Repair

UNIT V
17. Gene regulation in prokaryotes: DNA binding motifs, Lac operon, Tryptophan operon
18. Sex determination in *Drosophila*: Chromosomal & Molecular basis
19. Sex determination in mammals: Primary and Secondary sex determination
20. Basic concepts of Dosage compensation in *Drosophila* and mammals

**Suggested Readings:**
De Robertis & De Robertis. *Cell and Molecular Biology*. Lea & Febiger

**ZOOL. 104: TOOLS AND TECHNIQUES FOR BIOLOGY**

**UNIT I**

1. Microscopy, principle & applications of light microscope, phase contrast microscope and Fluorescence microscope
2. General principle and applications of Electron microscope (TEM & SEM)
3. Principle and applications of Confocal microscopy
4. Cryotechniques: Cryopreservation of cells, tissues, organs and organisms
   Freeze fracture & freeze drying

**UNIT II**

5. Principles and applications of photometry; Beer & Lambert’s law, Absorption spectrum & absorption maxima
6. Colorimeter & spectrophotometer: Working principle and applications
7. Flame photometer: Working principle and applications
8. Atomic absorption spectrophotometer: Working principle and applications

**UNIT III**

9. Separation techniques: Chromatography, principle, types and applications
10. Electrophoresis, principle, types & applications, PAGE and agarose gel electrophoresis
11. Radioisotopes in biology: Units of radioactivity, Radioactive counters
12. Autoradiography

UNIT IV

13. Techniques in immunodetection I: Immunocytochemistry and immunohistochemistry
14. Techniques in immunodetection II: Immunoblotting and immunofluorescence
15. Histological techniques: Principles and methods of perfusion, tissue fixation, Mmcrotomy, cryotomy, and histochemical staining; Stereotaxy
16. Immunological techniques: Immunodiffusion and Immuno-electrophoresis

UNIT V

17. Cell culture techniques: Design and functioning of tissue culture laboratory; Culture media, essential components and preparation; Cell viability testing
18. Cytological techniques: Mitotic & Meiotic chromosome preparations from insects and vertebrates
   Chromosome banding techniques (G-, C-, Q-, R- banding etc.)
19. Molecular cytological techniques: In situ hybridization (radiolabelled & non-radiolabelled methods), FISH, and Restriction banding
20. Molecular biology techniques: Southern hybridization and Northern hybridization
   DNA sequencing
   Polymerase chain reaction (PCR)

Suggested Readings:
Bisen: Laboratory protocols in applied lifescience. CRC Press, 2014
LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 105: INVERTEBRATES, QUANTITATIVE BIOLOGY & BIOINFORMATICS

(USE OF ANIMALS FOR DISSECTIONS TO BE RESTRICTED TO APPROVABLE SPECIES ONLY, ETHICAL COMMITTEES TO BE ESTABLISHED AND MADE FUNCTIONAL AS PER UGC NOTIFICATION PLEASE)

- Study of Protozoa in living state and permanent mounting
- Collection, preservation, staining, mounting and identification of different larvae, protozoans, sponges, coelenterates, helminths, particularly the following: Balantidium, Opalina, Nyctotherus, Monocystis, Euglena, Paramaecium, Plasmodium, Vorticella, Hydra, Sponges Rotifers, Ascaris, liverfluke etc.
- Mounting and identification of whole mounts of invertebrates their structural parts like gills, radula, statocyst, tentorium, tympanum spiracles Malphigian tubulites salivary, glands of insects, sting apparatus of honey bee, nephridia and ovary of earthworm, etc.
- Study of museum specimens of invertebrate animals
- Digital dissection of animals for demonstration of various internal structures: Starfish, Echinus, Holothuria, Pheretima, crab, Squilla, grasshopper, cockroach, scorpion, Mytilus, Octopus, Loligo, Sepia, Aplysia.
- Study of permanent slides of invertebrate animal materials
- Biostatistical problems: Preparation of charts, diagrams (bar, histograms, pie, graphs etc.), computation of mean, mode, median, standard deviation, standard error of classified data, chi square, t-test and ANOVA
- Statistical analysis of field data
- Computer applications in statistical problems
- Constructing mathematical models for simple zoological activities
- Solution and analysis of models
- Case studies of biological populations

SCHEME OF PRACTICAL EXAMINATION

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1. Major dissection of organ systems of invertebrate with display and diagram</td>
<td>15</td>
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<tr>
<td>2. Biostatistical problem</td>
<td>12</td>
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<tr>
<td>3. Exercise of computer application and bioinformatics</td>
<td>12</td>
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<tr>
<td>4. Preparation of stained permanent mount of nonchordate material with diagram and identification</td>
<td>06</td>
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<tr>
<td>5. Spotting 10x2.5 (museum specimens – 03, slides – 03, mathematical models – 02computer applications – 02)</td>
<td>25</td>
</tr>
<tr>
<td>6. Collection and preservation of specimen</td>
<td>10</td>
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<tr>
<td>7. Viva voce</td>
<td>10</td>
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<tr>
<td>8. Practical record</td>
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TOTAL MARKS 100
DURATION (HOURS) 06
## LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

**ZOOL. 106: MOLECULAR CELL BIOLOGY, GENETICS AND TOOLS & TECHNIQUES**

1. Microtomy of invertebrate or vertebrate materials
2. Preparation of buffer solutions of defined ionic concentration and determination of pH
3. Absorption spectrum of coloured and colourless solutions using spectrophotometer and colorimeter
4. Separation and detection of dyes/amino acids/sugars using paper chromatography and/or TLC
5. Study of permanent slides of cytology
6. Study of mitosis from onion root tips by making stained temporary squash preparation
7. Study of meiosis from testicular tissue of grasshopper
8. Salivary gland squash preparation for the study of polytene chromosomes of *Chironomus/Drosophila*
9. Mammalian blood smear preparation for the study of drumstick as sex chromatin test in rat/human
10. Study of Mendelian ratios from the seed coat colour pattern of seeds (monohybrid and dihybrid ratio)
11. Collection of *Drosophila* for the study of morphological characters of males and females
12. Study of cellular ultrastructure by means of electron micrographs
13. Working and applications of tools: B-Counter, ELISA reader and autoanalyser/spectrophotometer and image analyzer
14. Expts. In molecular biology

## SCHEME OF PRACTICAL EXAMINATION

<table>
<thead>
<tr>
<th>Exercise</th>
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<tbody>
<tr>
<td>1. Cytological / molecular biological / cytogenetic exercise</td>
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<tr>
<td>2. Microbiological/genetics exercise</td>
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<tr>
<td>3. Determination of pH, preparation of buffer, colorimetric or</td>
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<tr>
<td>spectrophotometric exercise</td>
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<td>4. Chromatographic separation (paper/thin layer) of biomolecules/</td>
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<tr>
<td>Working and applications of tools</td>
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<td>5. Spotting (cytological slides – 3, immunological tools – 2,</td>
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<tr>
<td>microbiological preparations –1, electron micrographs – 2)</td>
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<tr>
<td>6. Microtomy: (a) Sectioning &amp; stretching (b) staining &amp; mounting</td>
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<tr>
<td>7. <em>Viva voce</em></td>
<td>10</td>
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<td>8. Practical record</td>
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**TOTAL MARKS** 100  
**DURATION (HOURS)** 06
SECOND SEMESTER:

ZOOL. 201: GENERAL AND COMPARATIVE ANIMAL PHYSIOLOGY

UNIT I
1. Blood and circulation: Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis
2. Respiratory system: Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination
3. Respiratory pigments through different phylogenetic groups
4. Neural and chemical regulation of respiration.

UNIT II
5. Excretory system: Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, & micturition,
6. Regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.
7. Digestive system: Digestion, absorption, energy balance, BMR.
8. Thermoregulation: Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.

UNIT III
9. Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissues.
10. ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.
11. Nervous system: Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture.
12. Physiology of impulse transmission through nerves and synapse

UNIT IV
13. Comparative study of mechanoreception
14. Comparative study of photoreception
15. Comparative study of phonoreception
16. Comparative study of chemoreception

UNIT-V
18. Stress and adaptation
19. Endocrinology and reproduction: Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes.
20. Neuroendocrine regulation of Hormones, their classification and chemical nature

Suggested Readings:

Prosser, C.L. Comparative animal physiology. W.B. Saunders and Co.
Hoar, W.S. General and Comparative Animal Physiology.
Prosser, C.L. Environmental and Metabolic Physiology. Wiley-Liss, New York
1. Primary, secondary, tertiary and quaternary structures of proteins
2. Protein folding and denaturation
3. DNA: Double helical structure of DNA; Replication & Recombination
4. RNA: Types and structure of RNA; Cellular functions of different RNAs

UNIT II

5. Basic concept of metabolism: Coupled and interconnecting reactions of metabolism; cellular energy resources and ATP synthesis
6. Glycolysis and glyconeogenesis
7. Citric acid cycle; Oxidative phosphorylation
8. Pentose Phosphate Pathway and Glyconeogenesis.

UNIT III

9. Functional importance of lipid storage & membrane lipids; lipid storage diseases
10. Fatty acid metabolism: Synthesis and degradation of fatty acids
11. Protein Synthesis
12. Bile: Composition and functions; bile dysfunction associated diseases

UNIT IV

13. RNA synthesis and splicing
14. Biosynthesis of amino acids
15. Biosynthesis of nucleotides
16. Biosynthesis of membrane lipids and steroids

UNIT V

17. Enzymes: Basic concepts and kinetics
18. Mechanism and Regulation of enzyme catalysis
19. Concept of free energy and thermodynamic principles in biology
20. Energy rich bonds, compounds and biological energy transducers

Suggested Readings:

Segal, I.H. Biochemical Calculations. John Wiley and Sons
Freifelder, D. Essentials of Molecular Biology.
Cooper, T.G. Tools of Biochemistry.
Hawk. Practical Physiological Chemistry.
ZOOI. 203: POPULATION ECOLOGY AND ENVIRONMENTAL BIOLOGY

UNIT I
1. Biodiversity Conservation
2. Biodiversity laws, significance and management approaches.
3. Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection)
4. Concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

UNIT II
5. Case studies in population dynamics with two examples from areas such as fisheries and wildlife
6. Adaptation: Levels of adaptation, mechanisms and significance of body size
7. Biogeography: Major terrestrial biomes; biogeographical zones of India.
8. Aquatic environments: Freshwater, marine and estuarine environments

UNIT III
9. Eco-physiological adaptations to terrestrial, freshwater and marine water environments
10. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax
11. Environmental limiting factors
12. Concept of homeostasis

UNIT IV
13. Inter and intra specific relationship competition
14. Predatory-prey relationship, predator dynamics, optimal foraging theory
15. Mutualism, evolution of plant-pollinator interaction
16. Environmental pollution; global environmental change; Environmental impact assessment

UNIT V
17. Biodiversity-status, monitoring and documentation; major drivers of biodiversity change;
19. Sustainable development
20. Ecological modeling: Fundamentals of constructing models

Suggested Readings:

**ZOOL. 204: BIOSYSTEMATICS, TAXONOMY AND EVOLUTION**

**UNIT I**

1. Definition and basic concepts of biosystematics and taxonomy  
2. Trends in biosystematics: Chemotaxonomy, cytotaxonomy and molecular taxonomy  
3. Dimensions of speciation and taxonomic characters  
4. Species concept: Different species concepts  

**UNIT II**

5. Species category, sub-species and other infra-specific categories  
6. Theories of biological classification  
7. Taxonomic categories & Hierarchy of categories  
8. Taxonomic characters: Different kinds, origin of reproductive isolation, biological mechanism of genetic incompatibility  

**UNIT III**

9. Taxonomic procedures: Taxonomic collections, preservation, curetting, process of identification  
10. Taxonomic keys: Different kinds of keys, their merits and demerits  
11. International code of Zoological nomenclature (ICZN): Operative principles, interpretation & application of important rules, formation of scientific names of taxa  
12. Concepts of evolution and theories of organic evolution

**UNIT IV**

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

**UNIT V**

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

**Suggested Readings:**  
Mayor, E. *Elements of Taxonomy*.  
LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL - 205: PHYSIOLOGY AND BIOCHEMISTRY

- Detection of carbohydrates, proteins and lipids in the given sample
- Demonstration of salivary digestion
- Demonstration of gastric digestion
- Demonstration of pancreatic digestion
- Detection of urea, uric acid, ammonia in the given sample
- Counting of red blood corpuscles in the blood of rat or man
- Counting of white blood corpuscles in the blood of rat or man
- Determination of haemoglobin percentage in the blood of rat or man
- Detection of blood groups and Rh factor in rat or man
- Determination of rate of respiration in an insect, mammal or fish
- Determination of blood clotting time
- Preparation of haemin crystals
- Determination of Erythrocyte sedimentation rate (ESR)
- Separation of Serum and tissue protein with the help of electrophoresis
- Demonstration of reflex action
- Quantitative determination of biological parameters (protein, cholesterol and blood sugar, RNA and DNA etc.) with the help of colorimeter

SCHEME OF PRACTICAL EXAMINATION

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<tbody>
<tr>
<td>1.</td>
<td>Experiment on hematological parameter (Three)</td>
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<td>2.</td>
<td>Experiment on biochemical parameter (Two)</td>
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<td>3.</td>
<td>Qualitative enzymatic assay</td>
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<td>4.</td>
<td>Quantitative assay of a biochemical parameter (Two)</td>
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<td>5.</td>
<td>Viva voce</td>
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<td>6.</td>
<td>Practical record</td>
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<td>TOTAL MARKS</td>
<td>100</td>
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<td>DURATION (HOURS)</td>
<td>06</td>
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LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL-206: ECOLOGY, ENVIRONMENTAL PHYSIOLOGY, SYSTEMATICS, TAXONOMY AND EVOLUTION

- Water analysis for dissolved oxygen, free carbon-dioxide, chloride, pH, hardness and alkalinity
- Determination of climatic factors
- Composition and classification of soil, gravel, coarse and fine sands, clay, sand, clay-loam, loam, chalky and peaty
- Ecological niche: A habitat study
- Animal association and communities
- Population dispersion
- Identification and classification of important invertebrate groups
- Techniques of collection and preservation, mounting & display, indexing
- Structural adaptations of ecological significance
- Study of evolutionary trends through models etc.
- Problem related to evolution, population genetics etc. (natural selection, adaptation, trends of evolution, genetic polymorphism etc.)
- Preparation of phylogenetic tree using molecular data
- Toxicity tests: LC$_{50}$/LD$_{50}$

SCHEME OF PRACTICAL EXAMINATION

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<tbody>
<tr>
<td>1</td>
<td>Experiments of environmental biology/habitat study /community study (2)</td>
<td>20</td>
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<tr>
<td>2</td>
<td>Animal associations / Ecological adaptation (2)</td>
<td>10</td>
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<tr>
<td>3</td>
<td>Problems related to evolution (2)</td>
<td>20</td>
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<tr>
<td>4</td>
<td>Methods of collection, preservation and identification of invertebrate / vertebrate animals with comments (5 animals)</td>
<td>20</td>
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<tr>
<td>5</td>
<td>Mounting and display of two animals (invertebrates and vertebrates)</td>
<td>10</td>
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TOTAL MARKS 100
DURATION (HOURS) 06
THIRD SEMESTER:

ZOOL/301: COMPARATIVE ANATOMY OF VERTEBRATES

UNIT I

1. Origin of Chordata: Concept of Protochordata
2. Origin and classification of vertebrates
3. Vertebrate morphology: Definition, scope and importance
4. Development, structure and functions of vertebrate integument and its derivatives (glands, scales, feathers and hairs)

UNIT II

5. Respiratory system: Characters of respiratory tissue, external and internal respiration, comparative account of respiratory organs
6. Evolution of heart
7. Evolution of aortic arches and portal systems
8. Blood circulation in various vertebrate groups

UNIT III

9. Form, function, body size and skeletal elements of the body
10. Comparative account of jaw suspensorium and vertebral column
11. Comparative account of limbs and girdles
12. Evolution of urinogenital system in vertebrates

UNIT IV

13. Comparative account of organs of olfaction and taste
14. Comparative anatomy of brain and spinal cord (CNS)
15. Comparative account of peripheral and autonomic nervous system
16. Comparative account of lateral line system

UNIT V

17. Comparative account of electrorception
18. Comparative account of simple receptors
19. Flight adaptations in vertebrates
20. Aquatic adaptations in birds and mammals

Suggested Readings:

Kent, C.J. *Comparative Anatomy of Vertebrates*.
ZOOL/302: DEVELOPMENTAL BIOLOGY

UNIT I
1. Basis concepts of Development: Cell division and the cell cycle, Chromosomal puffs and gene activation, Cell commitment and differentiation (Specification, determination, induction competence, differentiation)
2. Morphogen gradients, cell fate, cell potancy and morphogenesis
3. Gametogenesis: Origin and migration of primordial germ cells; Production of male gametes (Spermatogenesis), Gene expression during spermatogenesis and sperm maturation,
4. Production of female gametes (oogenesis) (Previtellogenesis, vitellogenesis and maturation phase in development of amphibian egg); Gene expression during amphibian oogenesis; Ovulation and ovum transport in mammals

UNIT II
5. Fertilization and early development: Pre fertilization events (sperm penetration of egg and acrosomal reaction, binding of sperm to the egg, Blocks to polyspermy), Biochemistry of fertilization (metabolic activation of egg, penetration of spermatozoa into the egg, union of gametes), Post – fertilization events
6. Establishment of polarity in amphibians and birds
7. Gastrulation and formation of germ layers in mammals
8. Multiple ovulation and embryo transfer technology: In vitro oocyte maturation and super ovulation

UNIT III
9. Hormonal regulation of ovulation, pregnancy and parturition
10. Hormonal regulation of development of mammary glands and lactation
11. Endocrinology and physiology of placenta
12. Collection and cryo preservation of gametes and embryos

UNIT IV
13. Teratological effects of xenobiotics on gametes
14. Wolfian lens regeneration
15. Melanogenesis
16. Differentiation and development of gonads

UNIT V
17. Cell diversification in early embryos, xenopus blastomeres, totipotency & pleuripotency
18. Embryonic stem cells, chord-blood cells & their significance
19. Hemopoetic stem cells, formation of blood cells
20. Connective tissue cell family

Suggested Readings:

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 305: VERTEBRATES AND GENES, DEVELOPMENT & DIFFERENTIATION
(USE OF ANIMALS FOR DISSECTIONS TO BE RESTRICTED TO APPROVABLE SPECIES ONLY, ETHICAL COMMITTEES TO BE ESTABLISHED AND MADE FUNCTIONAL AS PER UGC NOTIFICATION PLEASE)

- Classification of lower chordates and study of representatives of various groups
- Dissection of different organ systems of the following animals: *Hardmania, Amphioxus*, bony fish and frog or toad
- Minor dissection and stained preparations from lower chordate animals
- Study of disarticulated skeleton of dog fish, bony fish and amphibians
- Study of permanent slides of Urochordata, Cephalochordata elasmobranchs, teleosts and amphibians
- Classification of Chordata and study of representatives of various groups
- Dissection of different organ system of the following animals: snake, *Hemitraclylus Calotes*, pigeon, rat etc.
- Minor dissection and stained preparation from above mentioned animals
- Study of disarticulated skeleton of various vertebrates
- Study of permanent slides of chordate materials
- Study of important characters of poisonous & non-poisonous snakes and their biting apparatus.
- Study of migratory and resident birds
- Study of animals of zoo including mammals
- Study of development of eggs of fish, frog, hen and invertebrates
- Study of distribution of RNA in developing eggs
- Study of effects of chemicals and temperature on developing eggs, polyploidy, aneuploidy
- Determination of respiratory rates of eggs
- Study of electron micrographs of spermatogenesis and oogenesis
- Study of of permanent slides of chick and frog gonads and embryology

SCHEME OF PRACTICAL EXAMINATION

1. Dissection of organ-systems and display with diagram of cartilagenous fish, bony fish, house lizard, garden lizard, pigeon or rat 15
2. Mounting of chordate material/Minor dissection with diagram (Hardmania, Amphioxus and the chordate material) 10
3. Preparation and mounting of developmental stages of frog, chick or any other suitable animal 15
4. Spotting (bones – 2, slides – 2, museum specimens – 2, embryological slides – 2, electron micrographs - 2) 30
5. Exercise based on poisonous & non-poisonous snakes/ migratory and resident birds / zoo animals 10
6. *Viva voce* 10
7. Practical record 10

TOTAL MARKS 100
DURATION (HOURS) 06
COURSES FOR SPECIAL (ELECTIVE) GROUPS:

A. AQUATIC BIOLOGY AND AQUACULTURE

ZOOL. 303 (A) AQUATIC ECOLOGY & RESOURCES

UNIT I

1. Aquatic ecology: Science and its development
2. Origin and classification of wetlands including lakes
3. Morphology of lakes, reservoirs and ponds
4. Physical chemical and biological characteristics of marine environment

UNIT II

5. Estuaries and other brackish water environments in India and their faunal importance
6. Physical and chemical characteristics of lakes, ponds and rivers
7. Freshwater biota: Plankton, benthos and macrophytes
8. Food chain, food web, trophic levels and energy flow

UNIT III

9. Primary productivity in Inland water and methods of its determination
10. Degradation of wetland in India and control measures
11. Aquatic resources: Invertebrates and vertebrates
12. Importance and management of aquatic resources in India

UNIT IV

13. Migration pattern of aquatic animals including aquatic birds
14. Threatened wetlands and endangered aquatic species
15. Aquatic wild life: Habitat and its importance, composition and conservation strategies
16. Aquatic pollution, its causes and control measures

UNIT V

17. Major sources of pollution in rivers and remedies
18. Biological indicators of water pollution
19. Eutrophication, its impact on water bodies and control measures
20. Aquatic toxicology: Aquatic toxicity, long-term toxicity and chronic toxicity
ZOOLO. 304 (A): FISH BIOLOGY & PHYSIOLOGY

UNIT I

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

UNIT II

5. Swim bladder and its functional significance
6. Food, feeding habits and nutrition in fish
7. Digestive system and physiology of digestion in fish
8. Osmoregulatory organs and osmoregulatory mechanisms in fish

UNIT III

9. Brain of fishes and its functional organization in relation to ecological conditions
10. Lateral line system: Structure, modifications and functional significance
11. Electric organs and their significance
12. Bioluminiscence in fish and its significance
13. Chemical communication in fish

UNIT IV

14. Neuro-endocrine integration and hypothalamo-hypophysial system in fish
15. Anatomy and physiology of pituitary gland
16. Anatomy and physiology of thyroid gland
17. Pineal organ, inter-renal gland and caudal neurosecretory system

UNIT V

18. Seasonal cycles of gonads in Indian fish
19. Hormonal and endocrine control of reproduction in fish
20. Development of teleost fish
21. Parental care in fish

Suggested Readings:

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 306 (A) AQUATIC BIOLOGY & AQUACULTURE

- Analysis of water samples for physico-chemical and biological characteristics including water depth, transparency turbidity, temperature, nutrients (Phosphates, nitrate, silicates), BOD, and COD and plankton
- Estimation of primary productivity by light and dark bottle experiment
- Macrobenthic fauna and its estimation
- Preparation of permanent mounts of planktonic organisms
- Physico-chemical analysis of soil of fish pond
- Field studies or river, stream and reservoir ecosystems, wetland sanctuaries and parks
- Microtomy of fish and shell fish material: block making, sectioning and staining
- Histology and histopathology of fish tissues
- Anatomy of fish, sexual dimorphism in carp and other fish
- Dissection of cranial nerves of catfishes and carps
- Gills and accessory respiratory organs of fishes
- Alimentary canals of carps, catfishes and murrels
- Biochemical estimation of fish constituents
- Acute toxicity determination for freshwater fish
- Experiments on fish behaviour
- Age determination with the help of scales and other materials

SCHEME OF PRACTICAL EXAMINATION

1. Dissection of cranial nerves of *Wallago* / *Mystus* / *Labeo* / *Torpedo* 15
2. Minor dissection of fish anatomy / alimentary canal / accessory respiratory organs / age determination / maturity stages/pigmentary behaviour 10
3. Estimation of physico-chemical characteristics of water / soil nutrient 10
4. Analysis / Primary productivity / identification of benthic / planktonic organisms / toxicity test 15
5. Spotting (histological / histopathological slides-3, museum specimens-3, bones-2) 30
6. Viva voce 10
7. Practical record /submission of charts /models / collection etc. 10

TOTAL MARKS 100
DURATION (HOURS) 06
B. CELL BIOLOGY

ZOOL. 303 (B): METHODS IN CELL & MOLECULAR BIOLOGY

UNIT I

1. Principle and applications of Nanodrop spectrophotometry
2. Cell sorting: Principle and applications of flow cytometer
3. Working principle and applications of fluorimeter
4. Working principle and applications of Atomic Force Microscope

UNIT II

5. Cell fractionation: Differential velocity and density gradient centrifugation
6. Basic idea of NMR and ESR
7. Basic idea of X-ray Crystallography
8. Gel Electrophoresis: 1D & 2D-PAGE and Isoelectric focusing

UNIT III

9. Immunotechniques: Precipitation, immunofluorescence, ELISA and RIA
10. Methods of protein purification
11. DNA-protein interactions: Electrophoretic mobility shift assay (gel shift assay), DNA footprinting
12. General idea of DNA micro-array, DNA chips and Affymetrix.

UNIT IV

13. Stem cells: Types, culture and applications
15. Methods in gene analysis-II: General idea of site directed mutagenesis, Linker scanning mutations analysis and Reporter assay
16. Recombinant DNA technology: Preparathion and applications of Transgenics and Knockouts

UNIT V

17. General idea of two-hybrid systems; Subtractive hybridization, Chromosome walking, Chromosome jumping and positional cloning
18. RNA analysis: General idea of RNAase protection assay, Primer extension, S1 nuclease protection assay for mapping ends/transcription site of RNA
19. Introduction to Genome analysis I: DNA finger printing, RAPD and RFLP
20. Introduction to Genome analysis II: General idea of SNPs & SNP typing; Elementary idea of Genome-wide analysis of sequences (DNA & RNA) and Next Generation Sequencing (NGS)
ZOOL. 304 (B): CELLULAR STRUCTURE MOLECULAR ORGANIZATION

UNIT I

1. General organization and characteristics of viruses (examples: SV40 & HIV)
2. Viral and Artificial chromosomes as cloning vectors and their applications (e.g., SV40, YAC, BAC, PAC, etc.)
3. Genome complexity: C-value paradox and cot value
4. DNA sequences of different complexity

UNIT II

5. Cytochemistry of Golgi complex and its role in cell secretion
6. Peroxisomes: Synthesis and targeting of peroxisomal proteins
7. Nucleolus: Structure and biogenesis of ribosomes
8. Intracellular digestion: Ultrastructure and functions of lysosomes

UNIT III

9. Synthesis and targeting of mitochondrial proteins
10. Secretary pathways and translocation of secretary proteins across the EPR membrane
11. Cell cycle regulation in *Xenopus*
12. Regulation of cell cycle in yeast

UNIT IV

13. Cell cycle: Cell cycle control in mammalian cells
15. Cell Signaling: Enzyme-linked signaling and cross-talk among various signaling pathways
16. Apoptosis: Molecular mechanism and significance

UNIT V

17. Differences between normal cells and cancer cells: Biochemical, cytoskeletal and cell surface changes
18. Genetic basis of human cancer
19. Chromosomal basis of cancer: Philadelphia chromosome (CML), Retinoblastoma, etc.
20. General idea of oncogenes and cancer; transforming agents, proto-oncogenes and tumor suppressor genes

Suggested Readings:
Gerald Karp. *Cell Biology*.
Lewin B. *Genes XI*.
King, *Cell Biology*. 
LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 306 (B) CELL BIOLOGY

- Histology and histochemistry: Microtomy and cryotomy, staining and detection of cell organelles (e.g., mitochondria, Golgi bodies, lysosomes, nucleus and nucleoli)
- Histochemical demonstration of lipids, proteins (including enzymes), carbohydrate and nucleic acids (DNA/RNA)
- Immunocytochemistry: Intracellular localization of specific target molecules by antibody staining
- Fluorescence microscopy and immunofluorescence: Application of fluorochromes and fluorochrome tagged antibodies in the demonstration of proteins and nucleic acids
- Gel electrophoresis of proteins: Separation of proteins on polyacrylamide gel electrophoresis (PAGE)
- Gel electrophoresis of nucleic acids (DNA/RNA) Isolation and detection of DNA/RNA on agarose gel
- Preparation of mitotic chromosomes from rat/mice bone marrow cells and construct karyotype of G-or C-banded chromosomes
- Short terms rat/human blood lymphocyte culture and preparation of mitotic chromosomes for karyotyping
- Study of permanent slides and electron micrographs

SCHEME OF PRACTICAL EXAMINATION

1. Histology and histochemistry: 
   a. Microtomy and slide preparation  
   b. Demonstration of biomolecules  
   20
2. Electrophoresis (PAGE/agarose)  
   (Demonstration of biomolecules on gel matrix)  
   20
3. Mitotic chromosome preparations and banding analysis  
   10
4. Spotting (permanent slides – 3, electron micrographs –5)  
   30
5. Viva voce  
   10
6. Practical record  
   10

TOTAL MARKS  100
DURATION (HOURS)  06
C. ENDOCRINOLOGY:

ZOOL. 303 (C): COMPARATIVE ENDOCRINOLOGY

UNIT I
1. History and scope of endocrinology
2. Endocrine methodologies
3. Mechanism of hormone action
4. Hormones and environment

UNIT II
5. General and comparative structure of anterior pituitary gland
6. General and comparative structure of neurohypophysis
7. General and comparative structure of thyroid
8. General and comparative structure of parathyroid

UNIT III
9. General and comparative structure of pancreas
10. Structure of mammalian pineal body
11. General and comparative structure of adrenal medulla and chromaffin tissue
12. General and comparative structure of adrenal cortex and inter-renal tissue

UNIT IV
13. Neurosecretion and neuroendocrine mechanisms in non-arthropod invertebrates
14. Neuroendocrine system in Crustacea
15. Neuroendocrine system in Insecta
16. Neuroendocrine system in Mollusca

UNIT V
17. Caudal neurosecretory system in fish
18. General structure of thymus
19. Endocrine integration: migration of birds and fishes, bird plumage
20. Hormone like substances: Ectohormones, phytohormones, root growth hormones,
ZOOL. 304 (C): ENDOCRINE PHYSIOLOGY

UNIT I
1. Role of hypothalamus and neuroendocrine integration in mammals
2. Hormones of anterior pituitary and their functional significance
3. Hormones of neurohypophysis and their functional significance in mammals
4. Hormones of pars-intermedia and control of pigmentary function in vertebrates

UNIT II
5. Functional significance of pineal hormones
6. Biosynthesis and functions of thyroid hormones
7. Regulation of thyroxine secretion
8. Thyroxine and its influence on development and metamorphosis

UNIT III
9. Parathyroid hormone and its physiological significance
10. Calcitonin, thyrocalcitonin and their functional significance
11. Catecholamines (epinephrine and nor-epinephrine) their biosynthesis and physiological influence on metabolism
12. Physiological significance of mineralocorticoids and glucocorticoids

UNIT IV
13. Gastrointestinal hormones and their physiological significance
14. Insulin and insulin like peptides and their role in early mammalian development
15. Renin and angiotensins and their functional significance
16. Physiological significance of insulin in carbohydrate metabolism

UNIT V
17. Physiological significance of glucagon in carbohydrate metabolism
18. Biochemistry and functional significance of sex steroids
19. Role of hormones in insect physiology
20. Role of hormones in crustacean physiology
LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 306 (C) COMPARATIVE ENDOCRINOLOGY & ENDOCRINE PHYSIOLOGY

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

SCHEME OF PRACTICAL EXAMINATION

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1.</td>
<td>Dissection of endocrine glands in vertebrate/invertebrate</td>
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<td>2.</td>
<td>Estimation of hormones in blood</td>
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<tr>
<td>3.</td>
<td>Quantitative estimation of proteins/cholesterol/blood sugar level</td>
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<td>4.</td>
<td>Microtomy of endocrine material</td>
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<td>5.</td>
<td>Separation of plasma proteins using electrophoresis</td>
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<td>6.</td>
<td>Study of Comparative structure of endocrine glands</td>
<td>10</td>
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<td>7.</td>
<td>Spotting (slides – 2, molecular structure of hormones – 2, electron micrograph – 2)</td>
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<td>8.</td>
<td>Viva voce</td>
<td>10</td>
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<td>9.</td>
<td>Practical record</td>
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TOTAL MARKS 100
DURATION (HOURS) 06
D. **ENTOMOLOGY**

**Zool. 303 (D): General Entomology & Insect Morphology**

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

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

**Unit III**
11. Structure of typical wing bearing thoracic segment
12. Structure of insect legs, their modifications and functions
13. Structure of insect wings, their modifications and wing coupling apparatus
14. Hypothetical wing venation

**Unit IV**
15. Wing venation in grasshopper, housefly and honeybee
16. Structure of flight muscles and flight mechanisms in insects
17. General structure of insect abdomen and its appendages
18. Male and female genitalia in grasshopper

**Unit V**
19. Sound production in insects
20. Sound reception in insects
21. Phase theory of locusts
22. Polymorphism in aphids
23. Methods of insect communication
Zool. 304 (A): Insect Anatomy and Physiology

Unit I
1. Structure and functions of insect integument
2. Mechanism of moulting and sclerotization of cuticle
3. Structure and types of spiracles
4. Tracheal system in a generalized insect and mechanism of respiration
5. Respiration in aquatic and parasitic insects

Unit II
6. Structure of Malphigian tubules including cryptonephridia
7. Physiology of excretion and significance of cryptonephridia
8. Structure of brain and ganglia
9. Variation in central nervous system in different insect orders

Unit III
10. Structure and functions of mechanoreceptors
11. Structure and functions of chemoreceptors
12. Photoreceptor organs: Simple and compound eyes, formation of image
13. Structure and functions of fat body

Unit IV
14. Composition and functions of haemolymph
15. Insect circulatory system
16. Digestive system: Structure and modifications of alimentary canal and associated glands
17. Histology of alimentary canal, salivary glands and peritrophic membrane
18. Physiology and regulation of digestion

Unit V
19. Neuroendocrine system and its variations in different insects
20. Chemistry and functions of hormones
21. Structure of male and female reproductive systems
22. Types of insect reproduction
23. Insect pheromones
LIST OF PRACTICAL EXERCISES

ZOOL. 306 (D): GENERAL ENTOMOLOGY

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

SCHEME OF PRACTICAL EXAMINATION

1. Dissection with display and diagram 20
2. Minor dissection/experiment with display and diagram 10
3. Mounting with identification, diagram and comments. 10
4. Physiological experiments/ biochemical analysis 10
5. Spotting (05) 30
6. Viva voce 10
7. Practical record 10

Total Marks 100
E. FISH BIOLOGY AND FISHERIES:

ZOOL. 303 (E): FISH STRUCTURE AND FUNCTION

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

UNIT II
6. Locomotion in fish
7. Structure and function of swim bladder
8. Accessory respiratory organs with special reference to Indian fishes
9. Different types of feeding and feeding habits of fish

UNIT III
10. Structure, function and homologies of Webarian ossicles
11. Hill stream adaptation in fish
12. Deep sea fishes
13. Migration in fish
14. Chemical communication in fish

UNIT IV
15. Structure and function of electric organs and electroreceptors
16. Structure and function of luminous organs
17. Structure and function of sound producing organs and sound reception
18. Poisonous and venomous fish.

UNIT V
19. Structure, working and functions of eye
20. Structure, working and functions of ear
21. Mendelian and non-Mendelian genetics in fish
22. Hybridization in fish
23. Sex determination in fish
ZOOL. 304 (E): FISH MORPHOLOGY, ANATOMY AND PHYSIOLOGY

UNIT I
1. Chromatophores: Classification, ultrastructure, and functional significance
2. Color changes: Types, neural and endocrine control mechanisms
3. Respiratory organs: Kinds and physiology of aqueous breathing
4. Digestive system: Anatomy and physiology of alimentary canal

UNIT II
5. Nervous system: Brain its functional organization with ecological bearing
6. Nervous system: Nerves and their supply
7. Lateral line system: structure, modifications and significance
8. Circulatory system in fish, heart, venous and arterial system

UNIT III
9. Excretory system: kidney and physiology of excretion in teleost fish
10. Osmo-regulatory organs and mechanisms in fish
11. Neuroendocrine integration in fish
12. Hypothalamo hypophysial neurosecretory system in fish

UNIT IV
13. Anatomy and physiology of the pituitary gland
14. Anatomy and physiology of the thyroid gland
15. Pineal organ, interrenal tissue and caudal neurosecretory system
16. Seasonal cycles of male and female gonads

UNIT V
17. Hormonal control of reproduction
18. Environmental control of reproduction
19. Early development of a teleost
20. Parental care in fish

Suggested Readings:
Leo. S.Berg Classification of fishes (fossiliged & Recent).
Francis day Vol I & II Fishes of India.
C.B.L Shrivastava, Fish Biology.
K.S. Mishra: An aid to classification of Fishes.
B.Qurashi: Identification of fishes.
W.D. Rusell: Aquatic Productivity.
K.F. Lagler: Ichthyology.
J.F. Norman: An History of fishes.
R.L. Rath: Fresh water Aquaculture.
H.R.Singh: Advance in fish Biodiversity.
Arugun & Natarajan: Fresh water Aquaculture.
Arugun & Natarajan: Santanu-Costal Aquaculture.

LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 306 (E): FISH BIOLOGY

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

SCHEME OF PRACTICAL EXAMINATION

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1. Dissection with display and diagram</td>
<td>20</td>
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<tr>
<td>2. Fish physiological exercise related to digestion respiration osmoregulation and colour change</td>
<td>10</td>
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<tr>
<td>3. Minor dissection with display and diagram</td>
<td>10</td>
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<tr>
<td>4. Mounting/skeletal preparation 02</td>
<td>10</td>
</tr>
<tr>
<td>5. Spotting (museum specimens-3, histological slides-3, bones-3)</td>
<td>30</td>
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<tr>
<td>6. <em>Viva voce</em></td>
<td>10</td>
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<tr>
<td>7. Practical record</td>
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TOTAL MARKS 100
DURATION (HOURS) 06
FOURTH SEMESTER:

ZOOL. 401: ANIMAL BEHAVIOUR

UNIT I
1. Introduction: Ethology as a branch of biology and animal psychology.
2. Classification of behavioral patterns, analysis of behaviour (ethogram)
3. Reflexes and complex behaviour
4. Perception of the environment: mechanical, electrical, chemical, olfactory, auditory and visual

UNIT II
5. Evolution and ultimate causation: Inheritance behaviour and relationships
6. Motivation: Drive, timing and interaction of drives, physiological basis of motivation, hormones and motivation, aggregation
7. Communication: Chemical, visual, light and audio, evolution of language
8. Ecological aspects of behaviour: Habitat selection, food selection, optimal foraging theory, anti-predator defenses, aggression

UNIT III
9. Homing, Behaviour, dispersal, host-parasite relations
10. Biological rhythms: Circadian and circannual rhythms
11. Orientation and navigation, migration of fishes, turtles and birds.
12. Learning and memory: Conditioning, habituation, insight learning, association learning, reasoning

UNIT IV
14. Social behaviour. aggregations, schooling in fishes, flocking in birds, herding in mammals, group selection, kin selection, altruism, reciprocal altruism, inclusive fitness,
15. Social organization in insects

UNIT V
17. Neural and hormonal control of behaviour
18. Genetic and environmental components in the development of behaviour
19. Bioluminescence
20. Electric organs and behavior

Suggested Readings:

Mishra.: Clinical Neuro-physiology. Churchill Livingstone

ZOOLO. 402: BIOLOGY OF PARASITISM AND VERTEBRATE IMMUNE SYSTEM

UNIT I
1. Parasitism: Concept, origin, evolution, advantages and disadvantages in the parasitic life
2. Modes of parasitic invasion: Passive, mechanical, active, contact, transovarial pathways of entry and sites of habitation
3. Host specificity: Definition, origin, types, structural, physiological & pathological response, tissue, ecological and phylogenetic response
4. Host-parasite system: Effects of parasites on hosts (mechanical, nutritional, destructive, toxic etc.)

UNIT II
5. Host reactions to parasites: Resistance, compatibility and immunity
6. Innate and acquired immunity
7. Cells of immune system and their differentiation
8. Nature of immune response: Antigenicity and immunogenicity, factors influencing immunogenicity, epitopes and haptens

UNIT III
9. Antigen Structure and functions of antibodies: Classes and subclasses, gross and fine structure, antibody mediated effector functions
10. -antibody interactions: Antibody affinity and avidity, gross reactivity, agglutination
11. Major histo-compatibility complex in mouse and HLA system in human: MHC haplotypes, class-I and class-II molecules, cellular distribution, peptide binding, expression and diversity, disease susceptibility and MHC/HLA
12. T-cell receptors: Isolation, molecular components and structure, T-cell maturation and thymus, T-cell activation mechanism, T-cell differentiation, cell death and T-cell population

UNIT IV
13. B-cell generation, activation and differentiation: B-cell receptors, selection of immature and self reactive B-cells, B-cell activation and proliferation, T-B- cell interactions, humoral immune response and kinetics
14. Cytokines: Structures and functions, cytokine receptor, cytokines and immune response
15. Complement system: Complement activation & biological consequences
16. Cell-mediated effector functions: Cell adhesion molecules, effector cells and molecules, CTL and NK cells- mechanisms of action, delayed type hypersensitivity

UNIT V
17. Immune response to infectious diseases: Immune response to viral, bacterial, protozoan and other parasitic worms
18. Vaccines: Types of vaccines, active and passive immunization
19. Immunodeficiency disorders: Primary immunodeficiencies, secondary or acquired immunodeficiencies (AIDS)
20. Transplantation: Immunological basis of graft rejection, general and specific immunosuppressive therapy

**Suggested Readings:**
Jones, A.W. *Introduction to Parasitology*. Addison-Wesley Reading, Mass
Kuby, *Immunology*. W.H. Freeman, USA.
Paul, W. *Fundamentals of Immunology*.

**LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE**

**ZOOL. 405: ANIMAL BEHAVIOUR, BIOLOGY OF PARASITISM & VERTEBRATE IMMUNE SYSTEM**

- Experiments on animals behaviour:
  - Exploratory behaviour in rats / mice
  - Parental care in rats / mice
  - Burrowing behaviour of blowfly larvae
  - Phototactic behaviour of blowfly larvae
  - Burrowing & geonegative behaviour of earthworms
  - Burrowing behaviour of turtles
  - Circadian rhythmicity in foraging behaviour of honeybees
  - T-Mare, Y- Mare

- Blood film preparation and identification of cells
- Study of protozoan and helminth parasites, parasitic adaptation in animals, parasitic invasions, host-parasite interaction
- Lymphoid organs & their microscopic organization
- Study of antigen-antibody interaction
- Immunodiffusion
- Immunoelectrophoresis
- ELISA
- Immunocytochemistry
- Immunodiagnosis (demonstration using commercial kits)

**SCHEME OF PRACTICAL EXAMINATION**

<table>
<thead>
<tr>
<th>Practical</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1. Immunological experiments (immunodiffusion / immunoelectrophoresis)</td>
<td>10</td>
</tr>
<tr>
<td>2. Immunocytochemistry / ELISA</td>
<td>10</td>
</tr>
<tr>
<td>3. Experiments on animal behaviour (02)</td>
<td>20</td>
</tr>
<tr>
<td>4. Identification &amp; comments upon 8 spots (parasitic adaptations in protozoans, helminthes &amp; other animals, parasitic invasion, host – parasite interaction &amp; animal behaviour)</td>
<td>30</td>
</tr>
<tr>
<td>5. Blood film preparation and identification of cells</td>
<td>10</td>
</tr>
<tr>
<td>6. Viva voce</td>
<td>10</td>
</tr>
<tr>
<td>7. Practical record</td>
<td>10</td>
</tr>
</tbody>
</table>

**TOTAL MARKS** | 100 |
COURSES FOR SPECIAL (ELECTIVE) GROUPS:

A. AQUATIC BIOLOGY AND AQUACULTURE

ZOOL. 403 (A) FISHERIES AND PISCICULTURE

UNIT I

1. Classification of commercially important fish fishes and shell fishes and their significance
2. Fishes and shell fishes of Madhya Pradesh
3. Reservoir and lake fisheries (with emphasis on Tighra reservoir)
4. Reverine fisheries
5. Estuarine and brackish water fisheries

UNIT II

6. Marine fisheries of India
7. Environmental factors (a biotic and biotic) in relation to life of fishes
8. Exotic fishes, larvicidal fishes and their significance
9. Common parasites of fishes, fish diseases, their control and treatment
10. Economic importance of fishes and their by-products

UNIT III

11. Cultivable species of inland fishes and principle of their selection
12. Predatory fishes and their importance in fish culture
13. Plankton and their importance in fish culture
14. Fish ponds and their hydrobiological requirements,
15. Principles of genetics, hybridization and sex determination in fish

UNIT IV

16. Transgenic fish, formation and importance
17. Traditional verses modern fish culture practices
18. Paddy cum fish culture and its significance
19. Sewage fish culture and its importance
20. Fish net, gears and method of fishing

UNIT V

21. Fish preservation technology and packaging
22. Marketing of fishes and role of co-operative societies
23. Fisheries and rural development
24. Fisheries legislation
25. Fisheries development in Madhya Pradesh
ZOOLO. 404 (A): AQUACULTURE

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

UNIT II
5. Transport of live fish and fish seed
6. Planning and management of brackish-water fish farms
7. Nutritional requirements of fish and artificial diet
8. Freshwater aquaculture, prospects and management
9. Methods of aquaculture: Pen culture, cage culture, bottom and off bottom culture

UNIT III
10. Integrated fish farming in India: Agriculture-cum-fishery, trapa-cum-fishery, poultry-cum-fishery, piggery-cum-fishery, poultry-piggery-fishery
11. Economical aspect of fish culture management
12. Freshwater prawn culture practice in India
13. Brackish water prawn culture development in India

UNIT IV
14. Prospects and development of mariculture: Pearl culture, mussel culture and oyster culture
15. Frog culture: Species, breeding, culture and polyculture with fish
16. Culture of freshwater macrophytes (Azolla) and algae (Spirulina)
17. Prospects and development of turtle fishery

UNIT V
18. Breeding and rearing of crocodiles, crocodile industry: Indian and international perspective
19. Production of Jayanti culture of fresh water oyster for pearls, and sea weed culture
20. Whaling industry: Sustainable utilization
21. Major aquatic resources: Export and economic status in India

Suggested Readings:
Nikolsky, G.V. The Ecology of Fishes. Academic Press.
Srivastava, C.B.L. Fishery science and fisheries Kitab Mahal.

Santhanam, R. Ramanathan, N. and Jegatheesan, G. *Coastal Aquaculture in India* CBS Pub.
Chakraborty, C. and Sadhu, A.K. *Biology Hatchery and Culture technology of Tiger prawn and giant freshwater prawn* Daya Pub. House, Delhi
Wetzel, R. G. *Limnology Lake and Reservoir ecosystems* Academe Press.

**LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE**

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

**SCHEME OF PRACTICAL EXAMINATION**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Identification of freshwater prawns, fishes, frogs, turtles &amp; crocodiles up to species with biometric data</td>
<td>20</td>
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<tr>
<td>2.</td>
<td>Experiments on carp breeding through hypophysation / cultures of plankton / identification fish fry, fingerlings, post-larvae of prawns</td>
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<tr>
<td>3.</td>
<td>Identification &amp; comment upon common weeds, predator fishes, insects, other aquatic organisms harmful to fishes, nets, gears, crafts, sampling tools and apparatuses</td>
<td>30</td>
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<tr>
<td>5.</td>
<td><strong>Viva voce</strong></td>
<td>10</td>
</tr>
<tr>
<td>6.</td>
<td>Practical record, visit / survey report / materials, charts, models, specimens</td>
<td>10</td>
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<tr>
<td>7.</td>
<td><strong>Seminar</strong></td>
<td>10</td>
</tr>
</tbody>
</table>

**TOTAL MARKS** 100
B. CELL BIOLOGY

ZOOL. 403 (B): NEUROBIOLOGY AND AGEING

Unit-I
1. Gross organization of the nervous system.
4. Axons and dendrites

Unit-II
5. Synaptic transmission and cellular signaling.
7. Intercellular and intracellular signaling.
9. Neurotransmitter and disorders of the basal ganglia.

Unit-III
10. Glial cells: Types, structure and functions.
11. Astrocytes.
12. Oligodendrocytes and Schwan cells

Unit-IV
14. Introduction to sensory and motor system.
15. Visual system.
16. Auditory system.
17. Chemical senses.
18. Component of motor system, spinal reflexes and control of movements.

Unit-V
19. Aging: Theories of aging and concepts.
20. Age associated neurodegenerative diseases: Alzheimer’s and Parkinson’s diseases.
21. Role of neuroinflammation in neurodegenerative diseases.
22. Neuroimaging techniques.

Suggested Books:
ZOOLO 404 (B): CHROMOSOME, GENES & GENETICS OF DEVELOPMENT

UNIT I

1. Molecular Organization of eukaryotic chromosome: Structure of nucleosome particles and higher order compaction of mitotic chromosomes; chromatin remodelling
2. Specialized chromosomes: Structural organization and functional significance of polytene chromosomes
3. DNA methylation and DNAase: I Hypersensitivity in relational to chromatin organization and gene activity
4. Organization and significance of heterochromatin & Repetitive DNA

UNIT II

5. Structural organization of eukaryotic genes: Interrupted genes and overlapping genes
6. Gene families: Organization, evolution and significance
7. Transposable genetic elements of prokaryotes and eukaryotes
8. Recombination in Bacteria: Transformation, Conjugation & Transduction

UNIT III

9. Organization of eukaryotic transcriptional machinery: promoter, enhancer, RNA polymerases, activators and repressors
10. Transcription factor: DNA binding domains and activation domains, Types of DBD (zinc finger steroid receptors, homeo domains, Helix loop, Helix and Leucine Zipper)
11. Eukaryotic transcription and mechanisms of transcriptional control

UNIT IV

13. Genetic basis of thalasemias, muscular dystrophy and cystic fibrosis
14. DNA rearrangement: Amplification during development with special responses to,
   (a) Ciliate protozoans
   (b) Drosophila Chorion gene
   (c) Xenopus 5S RNA genes
15. Concept of pattern formation: Vulva formation in Cenorhabditis elegans.
16. Drosophila development I: (a) Cleavage and (b) Gastrulation

UNIT V

17. Drosophila development II: Origin of anterior and posterior polarity (maternal effect genes and segmentation genes)
18. Drosophila Development II: Origin of dorsal and ventral polarity
19. Basic idea of homeotic selector genes and homeotic mutations
20. Basic idea of organization of homeoboxes & Evolutionary significance of homeboxes

Suggested Readings:
Karp, Gerald Cell Biology.
Lewin, B. Genes VII
King. Cell Biology.
Travers, J. Immunology. Current Biology Limited.
Roitt, Male, Snustad, Immunology.
LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 406 (B) CELL BIOLOGY

- Preparation of Mitotic chromosomes from fish Kidney or bone marrow of bird.
- Preparation of polytene chromosomes from natural population of *Drosophila* or *Chironomous* to study chromosomal rearrangement (e.g., inversion, translocation etc.).
- Study of meiosis in rat/grasshopper testis.
- Histochemical and fluorescence localization of age pigments (e.g. lipofuscin and ceroids) in rat/mice.
- Study of chromatophores: hormonal and pharmacological treatments.
- Study of immune cells in cytological preparation.
- Study of monohybrid and dihybrid crosses/sex linkage in *Drosophila*.
- Study of development (homeotic) and other phenotypic Mutants of *Drosophila*.
- Methods in immunodetection: Western blotting, immunofluorescence, immunocytoLOGY, etc.

SCHEME OF PRACTICAL EXAMINATION

2. Study of chromatophores (hormonal and pharmacological treatments)/experiments in neurobiology 10
3. Experiment/demonstration in human genetics / genomics / DNA isolation from mammalian tissues /RE analysis / Study of age pigments in rats / mice 10
4. Spotting: Permanent slides (3), development & phenotypic mutants (3) demonstrations in human genetics (2) 30
5. *Viva voce* 10
6. Practical record 10
7. Seminar 10

TOTAL MARKS 100
C. ENDOCRINOLOGY

ZOOL. 403 (C); MALE REPRODUCTIVE ENDOCRINOLOGY

UNIT I

1. Differentiation of the testes and male genital ducts
2. Histology of testes, epididymis, vas deferens and seminal vesicles
3. Ultrastructure of testes
4. Structure and ultrastructure of mammalian sperm

UNIT II

5. Blood – testis barrier
6. Hormonal regulation and Spermatogenic function of the testis
7. Structure and functional significance of Sertoli cells
8. Structure and functional role of Leydig cells

UNIT III

9. Metabolism and biosynthesis of androgens
10. Biochemistry of semen
11. Maturation, transport and fate of spermatozoa in epididymis
12. Capacitation of spermatozoa

UNIT IV

13. Endocrine physiology of epididymis and seminal vesicles
14. Structure and function of coagulating glands, prostatic complex, Couper's gland and paraputial gland
15. Inhibin and activin
16. Sperm motility

UNIT V

17. Contraception through male
18. Effects of environmental factors on testicular function
19. Biological aspects of vasectomy
20. Male infertility
ZOOL. 404 (C): FEMALE REPRODUCTIVE ENDOCRINOLOGY

UNIT I

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

UNIT II

5. Menstrual cycle in primates
6. Endocrine control of structure and function of mammalian oviduct
7. Oviducal fluid: composition and physiology
8. Puberty and its hormonal control

UNIT III

9. Implantation and its hormonal regulation
10. Pregnancy and its hormonal regulation
11. Hormonal regulation of parturition
12. Lactation and its regulation

UNIT IV

13. Placenta: Fine structure and types
14. Placental hormones and their significance
15. Corpus luteum and its functional significance
16. Prostaglandins and their role in reproduction

UNIT V

17. Physiological role of ovarian steroidal hormones
18. Chemistry and functions of human chorionic gonadotropin
19. Delayed implantation and its mechanism
20. Control of fertility in females

Suggested Readings:
Hadley, M.E. Endocrinology.
LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

ZOOL. 406 (C) REPRODUCTIVE ENDOCRINOLOGY

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

SCHEME OF PRACTICAL EXAMINATION

1. Dissection of reproductive organs, accessory glands with display and diagram. 10
2. Experiments on living rats 10
3. Separation of steroids with TLC / pregnancy test 10
4. Preparation of vaginal /sperm smear 10
5. Spotting (slides – 4, chemical structure – 3, electron micrographs – 3) 30
6. Viva voce 10
7. Practical record 10
8. Seminar 10

TOTAL MARKS 100
D. **ENTOMOLOGY**

**Zool. 403 (D): Insect Taxonomy, Ecology & Development**

**Unit I**

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

**Unit II**

6. Classification of the Hemiptera upto families with distinguishing characters, economic importance and examples
7. Classification of the Isoptera upto families with distinguishing characters, economic importance and examples
8. Classification of the Odonata upto families with distinguishing characters, economic importance and examples
9. Classification of the Thysanoptera upto families with distinguishing characters, economic importance and examples

**Unit III**

10. Classification of Endopterygota upto orders with distinctive features and examples
11. Classification of the Lepidoptera upto families with distinguishing characters, economic importance and examples
12. Classification of the Diptera upto families with distinguishing characters, economic importance and examples
13. Classification of the Hymenoptera upto families with distinguishing characters, economic importance and examples
14. Classification of the Coleoptera upto families with distinguishing characters, economic importance and examples

**Unit IV**

15. Social organization in termites
16. Social organization in honey bees
17. Influence of climatic factors on insect populations
18. Adaptations of insects to their surroundings (aquatic, terrestrial and parasitic)
19. Phytophagy in insects, insect-host plant relationship

**Unit V**

20. Structure of insect eggs, development of upto formation of germ bands
21. Development and fate of embryonic membranes
22. Metamorphosis in insects
23. Types of insect larvae and pupae
24. Insect diapause
Zool. 404 (A): Applied Entomology

Unit I

1. Beneficial insects
2. Apiculture and beekeeping
3. Lac Culture
4. Sericulture

Unit II

5. Role of insects in plant pollination
6. Insects pests: Classification and categories of pests, origin and emergence of pests, pest out breaks and pest resurgence
7. Structure, life history, significance, nature of damage and control methods of following pests of sugarcane: (a) *Scirpophaga* (b) *Chilotracea* (c) *Pyrilla* (d) *Aleurolobus*
8. Structure, life history, significance, nature of damage and control methods of following cotton pests: (a) *Sylepta* (b) *Erias* (c) *Pectinophara* (d) *Dysdercu*

Unit III

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

Unit IV

14. Role of insect as vectors of human diseases
15. Mosquitoes as pests of public health importance and their control.
17. Live-stocks pests and their control
18. Different measures of insect pest control

Unit V

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

6. Smith, K.G.V. Insects and other Arthropods of Medical Importance.

LIST OF PRACTICAL EXERCISES

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

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

SCHEME OF PRACTICAL EXAMINATION

1. Identification of insects (5) up to orders 10
2. Identification of insects (5) families 10
3. Identification of insects (5) up to species 10
4. Spotting related to applied entomology 30
5. Experiment on insect control / field study 10
6. Viva voce 10
7. Practical record including collection & display 10
8. Seminar 10

Total Marks 100
E. FISH BIOLOGY AND FISHERIES:

ZOOL. 403 (E): TAXONOMY, SYSTEMATICS AND ECOLOGY OF FISHES

UNIT I

1. Outline classification of fishes as proposed by Berg
2. Classification of Elasmobranchii
3. Classification of Crossopterygii
4. Classification of Actinopterygii

UNIT II

5. Systematic survey of fish with particular reference to inland fishes of M.P.
6. Exotic fishes and their importance
7. Larvicidal fishes and their importance in public health
8. Predatory fishes and their significance in fish culture

UNIT III

9. Working and maintenance of fish aquarium
10. Fish nets and gears and methods of fishing
11. Fish diseases, symptoms and treatment
12. Common weeds of fish ponds and their control
13. Fish parasites and their control

UNIT IV

14. Physico-chemical characteristics of fish pond
15. Biological characteristics of fish pond
16. Culturable species of fishes of inland water and basis of their selection
17. Plankton and their significance in fish culture

UNIT V

18. Primary productivity of fish ponds and its significance
19. Aquatic macrophytes and culture of Azolla
20. Aquatic algae and culture of Spirulina
21. Sea weeds and their significance
ZOOLO. 404 (E): PISCICULTURE AND ECONOMIC IMPORTANCE OF FISHES

UNIT I

1. Collection of fish seed from natural resources
2. Dry bundh breeding of carps
3. Wet bundh breeding of carps
4. Hypophysation and breeding of Indian major carps
5. Drugs useful in induced breeding of fish

UNIT II

6. Types of ponds required for fish culture farms
7. Management of hatcheries, nurseries and rearing ponds
8. Management of stocking ponds
9. Composite fish culture
10. Integrated fish culture in India

UNIT III

11. Fresh water and brackish water Prawn culture in India
12. Pearl Oysters and pearl culture in India
13. Edible Oysters and Oyster culture in India
14. Methods of fish preservation
15. Marketing of fish in India

UNIT IV

16. Economic importance and by-products of fishes
17. Shark liver oil industry in India
18. Transport of live fish and fish seed
19. Fisheries and prawn resources of M.P.

UNIT V

20. Riverine fisheries in India
21. Coastal fisheries in India
22. Offshore and deep sea fisheries in India
23. Role of fisheries in rural development
24. Fishery co-operative societies and their role in development of fisheries
Suggested Readings:


LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE

**ZOOL. 406 (E): FISH BIOLOGY AND FISHERIES**

- Systematic identification of freshwater fishes with particular reference to M.P.
- Age determination with the help of scales / otolith
- Pigmentary behaviour in fish
- Qualitative zooplankton analysis
- Nutrient analysis of water
- Analysis of gut contents
- Microtomy of fish materials

**SCHEME OF PRACTICAL EXAMINATION**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1. Systematic identification of fishes (5) up to species</td>
<td>20</td>
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<tr>
<td>2. Identification of zooplankton / age determination (scales &amp; otolith)</td>
<td>15</td>
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<tr>
<td>3. Analysis of nutrients/maturity stage of fish</td>
<td>15</td>
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<tr>
<td>4. Microtomy of fish material (sectioning of wax blocks, stretching, &amp; double or triple staining)</td>
<td>20</td>
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<tr>
<td>5. <em>Viva -voce</em></td>
<td>10</td>
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<tr>
<td>6. Practical Record, project report, exertions report etc.</td>
<td>10</td>
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<tr>
<td>7. Seminar</td>
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TOTAL MARKS: 100
DURATION (HOURS): 06