

**JIWAJI UNIVERSITY  
GWALIOR**



**MASTER OF SCIENCE  
ZOOLOGY**

**SYLLABUS**

**(2014-2016)**

# **JIWAJI UNIVERSITY, GWALIOR**

## **MASTER OF SCIENCE**

### **ZOOLOGY**

**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**

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

## DETAILED SYLLABUS

### FIRST SEMESTER:

## **ZOOL. 101: STRUCTURE AND FUNCTION OF INVERTEBRATES**

### UNIT I

1. Organization of coelom: Acoelomates, Pseudocoelomates and coelomates
2. Protostomia and Dueterostomia
3. Locomotion: Flagellar and cilliary 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 Malpighian 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 Barnes, R.D. **Invertebrate Zoology, 3<sup>rd</sup> edition.** W.B. Saunders Co., Philadelphia.  
Barrington, E.J.W. **Invertebrate Structure and Function.** Thomas Nelson and Sons Ltd., London.
22. Sedgwick, A.A. **Student Text Book of Zoo**
23. Organization and general characters of Phoronida

### **Suggested Readings:**

Hyman, L.H. **The Invertebrates. Vol - I Protozoa through Ctenophora.** McGraw Hill Co., New York.

Hyman, L.H. **The Invertebrates. Vol. – II.** McGraw Hill Co., New York.

Hyman, L.H. **The Invertebrates. Vol. - VIII.** McGraw Hill Co., New York and London.

**logy. Vol. I, II and III.** Central Book Depot, Allahabad.

Parker, T.J., Haswell, W.A. **Text Book of Zoology.** Macmillan Co., London.

## **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., GENEbank, 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:**

- Batschelet, E. **Introduction to Mathematics for Life Scientists**. Springer-Verlag, Berlin.
- Jorgenson, S.E. **Fundamentals of Ecological Modelling**. Elsevier, New York.
- Swartzman, G.L and S.P.O. Kaluzny. **Ecological Simulation Primer**. Macmillan, New York.
- Lendren, D. **Modelling in Behavioral Ecology**. Chapman and Hall, London, UK.
- Sokal, R.R. and F.J. Rohlf. **Biometry**. Freeman, San Fransisco.
- Snedecor, G.W. and W.G. Cochran. **Statistical Methods**. Affiliated East-West Press, New Delhi (Indian Ed.)
- Green, R.H. **Sampling, Design and Statistical Methods for Environmental Biologists**. John Wiley & Sons, New York.
- Murray, J.D. **Mathematical Biology**. Springer-Verlag, Berlin.
- 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).

- Brown, S.M. **Bioinformatics- A Biologists Guide to Biocomputing and Internet**. Eaton Publishing, New York, 2000.
- Lesk, A.M. **Introduction to Bioinformatics**. Oxford, 2002.
- Bioinformatics - **Methods and Protocols**. In: **Methods in Molecular Biology**. Vol.132, Humana press, 2001
- Higgins & Taylor. **Bioinformatics - Sequence, Structure and Databanks**. Oxford, 2000.
- Baxevanis and Ouellette. **Bioinformatics**. John Wiley & Sons, 1998.
- Swindell. **Internet for the Molecular Biologists III**. Horizon Scientific, 1996.
- Peruski & Peruski. **The Internet and New Biology**. ASM, 1997.
- Gibson, G. & S.V. Muse. **A Primer of Genome Science**. Sinauer Associates Inc. Publishers, 2002.
- Krane and Raymer. **Fundamental Concept of Bioinformatics**. Pearson Education, 2003.
- Awesthead, Parish and Twyman. **Instant Notes: Bioinformatics**. Viva Book Pvt. Ltd., 2003.
- Attwood and Parry-Smith. **Introduction to Bioinformatics**. Pearson Education, 2003.
- Kothari C. R., **Research Methodology: Methods & Techniques**. New Age Publ., New Delhi, 2012
- 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)
3. Cytoskeleton: Microfilaments: structure dynamics and functions, Intermediate filaments: structure, dynamics and functions, Microtubules: structure, dynamics and functions
4. intracellular transport: Axonal transport, Transport of pigment in melanophores: Role of kinesin and dynein

### **UNIT II**

5. Cell - cell adhesion and cell junctions: Collagen and Non-collagen components of extracellular matrix of animal cells, Fibronectins and Integrins, Cell adhesion proteins & their types.
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**

13. Genome organization: Molecular organization of Gene & Chromosomal organization of Gene
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:**

- Alberts et al. **Essential Cell Biology**. Garland Publishing Inc., New York, 1998.
- Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson. **Molecular Biology of the Cell**. B. Garland Publishing Inc., New York, 2001.
- Boney. **Cell Biology Level II**. Macdonald & Evans, 1982.
- Darnell, J., H. Lodish and D. Baltimore. **Molecular Cell Biology**. Scientific American Book, Inc., USA
- De Robertis & De Robertis. **Cell and Molecular Biology**. Lea & Febiger
- Gilbert. **Developmental Biology**. Sinauer, 2000.
- Karp. **Cell and Molecular Biology**. John Willey & Sons, New York, 1996.
- Lodish et al. **Molecular Cell Biology**. Freeman & Co., 2000.
- Tobin and Morcel. **Asking about Cells**. Saunders, 1997.

### **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, Mmrotomy, cryotomy, and histochemical staining; Stereotaxy

16. Immunological techniques: Immunodiffusion and Imunoelectrophoresis

### 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

Clark & Switzer. **Experimental Biochemistry**. Freeman, 2000.

Locquin and Langeron. **Handbook of Microscopy**. Butterwaths, 1983.

Boyer. **Modern Experimental Biochemistry**. Benjamin, 1993.

Freifelder. **Physical Biochemistry**. Freeman, 1982.

Wilson and Walker. **Practical Biochemistry**. Cambridge, 2000.

Cooper. **The Cell -A Molecular Approach**. ASM, 1997.

John R. W. Masters. **Animal Cell culture- A practical approach**. IRL Press.

Robert Braun. **Introduction to instrumental analysis**. McGraw Hill Int. Ed.K. Wilson & K. H. Goulding. A Biologist's Guide to Principles & Techniques of Practical Biochemistry. ELBS Ed.



## 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, Paramecium, 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 Malpighian tubules 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

1. Major dissection of organ systems of invertebrate with display and diagram	15
2. Biostatistical problem	12
3. Exercise of computer application and bioinformatics	12
4. Preparation of stained permanent mount of nonchordate material with diagram and identification	06
5. Spotting 10x2.5 (museum specimens – 03, slides – 03, mathematical models – 02 computer applications – 02)	25
6. Collection and preservation of specimen	10
6. <i>Viva voce</i>	10
7. Practical record	10
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TOTAL MARKS	100
DURATION (HOURS)	06
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**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**

1. Cytological / molecular biological / cytogenetic exercise	12
2. Microbiological/genetics exercise	12
3. Determination of pH, preparation of buffer, colorimetric or spectrophotometric exercise	12
4. Chromatographic separation (paper/thin layer ) of biomolecules/ Working and applications of tools	12
5. Spotting (cytological slides – 3, immunological tools – 2, microbiological preparations –1, electron micrographs – 2)	24
6. Microtomy: (a) Sectioning & stretching (b) staining & mounting	08
7. <i>Viva voce</i>	10
8. Practical record	10
<b>TOTAL MARKS</b>	<b>100</b>
<b>DURATION (HOURS)</b>	<b>06</b>

## **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

17. Sense organs: Vision, hearing and tactile response.
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.  
Eckert, R. **Animal physiology - Mechanisms and adaptation**. W.H. Freeman and Co.  
Hoar, W.S. **General and Comparative Animal Physiology**.  
Schiemdt-Neilsen. **Animal Physiology: Adaptation and Environment**. Cambridge  
Prosser, C.L. **Environmental and Metabolic Physiology**. Wiley-Liss, New York

## ZOOL. 202: BIOMOLECULES, STRUCTURE & FUNCTIONS

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:

Voet, D. and J.G. Voet. **Biochemistry**. John Wiley & Sons.  
Freifelder, D. **Physical Biochemistry**. W.H. Freeman & Co.  
Segal, I.H. **Biochemical Calculations**. John Wiley and Sons  
Creighton, T.E. **Protein Structure and Molecular Properties**. W.H. Freeman & Co.  
Freifelder, D. **Essentials of Molecular Biology**.  
Cooper, T.G. **Tools of Biochemistry**.  
Hawk. **Practical Physiological Chemistry**.  
Garret, R.H. and C.M.Grisham. **Biochemistry**. Saunders College Publishers.

## **ZOOL. 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, interdemec 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, fresh water 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;.
18. Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).
19. Sustainable development
20. Ecological modeling: Fundamentals of constructing models

### **Suggested Readings:**

- Cherrett, J.M. **Ecological Concepts**. Blackwell Science Publication, Oxford, U.K.
- Elseth, B.D. and K.M. Baumgartner, **Population Biology**. Van Nostrand Co., New York.
- Jorgensen, S.E. **Fundamentals of Ecological Modeling**. Elsevier, New York.
- Krebs, C.J. **Ecology**. Harper & Row, New York.
- Krebs, C.J. **Ecological Methodology**. Harper & Row, New York.
- Eckert, R. **Animal Physiology: Mechanisms and Adaptation**. W.H. Freeman and Co., New York.
- Hochachka, P.W. and G.N. Somero. **Biochemical Adaptation**. Priceton, New Jersey.
- Schiemdt Nielsen. **Animal Physiology: Adaptation and Environment**. Cambridge.
- Willmer, P.G. Stone and Johnston. **Environmental Physiology**. Blackwell Science Publication, Oxford, U.K.
- Louw, G.N. **Physiological Animal Ecology**. Longman Harloss, UK.

## **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, curation, 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:**

- Kato, M. **The Biology of Biodiversity**. Springer.
- Avise, J.C. **Molecular Markers, Natural History and Evolution**. Chapman & Hall, New York.
- Wilson, E.O. **Biodiversity**. Academic Press, Washington.
- Simpson, G.G. **Principles of Animal Taxonomy**. Oxford IBH Publishing Company.
- Mayr, E. **Elements of Taxonomy**.
- Wilson, E.O. **The Diversity of Life** (College Edition). W.W. Norton & Co.

Tikadar, B.K. **Threatened Animals of India**. ZSI Publication, Calcutta.  
 Dobzhansky, Th. **Genetics and Origin of Species**. Columbia University, Press  
 Dobzhansky, Th., F.J. Ayala, G.L. Stebbins and J.M. Valetine. **Evolution**. Surjeet Publication, Delhi.  
 Futuyama, D.J. **Evolutionary Biology**. Suinuaer Associates, INC Publishers, Dunderland.  
 Jha, A.P. **Genes and Evolution**. John Publication, New Delhi  
 Merrel, D.J. **Evolution and Genetics**. Holt, Rinchart and Winston, Inc.  
 Strikberger, M.W. Jones and Bartett Publisher, Boston London

## 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

1. Experiment on hematological parameter (Three)	30
2. Experiment on biochemical parameter (Two)	20
3. Qualitative enzymatic assay	10
4. Quantitative assay of a biochemical parameter (Two)	20
5. <i>Viva voce</i>	10
6. Practical record	10
<b>TOTAL MARKS</b>	<b>100</b>
<b>DURATION (HOURS)</b>	<b>06</b>

**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<sub>50</sub>/LD<sub>50</sub>

**SCHEME OF PRACTICAL EXAMINATION**

1. Experiments of environmental biology/habitat study /community study(2)	20
2. Animal associations / Ecological adaptation (2)	10
3. Problems related to evolution (2)	20
4. Methods of collection, preservation and identification of invertebrate / vertebrate animals with comments (5 animals)	20
5. Mounting and display of two animals (invertebrates and vertebrates)	10
6. <i>Viva voce</i>	10
7. Practical record	10
<b>TOTAL MARKS</b>	<b>100</b>
<b>DURATION (HOURS)</b>	<b>06</b>



### **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 electroreception
18. Comparative account of simple receptors
19. Flight adaptations in vertebrates
20. Aquatic adaptations in birds and mammals

#### **Suggested Readings:**

- Young, J.Z. **Life of Vertebrates**. Oxford University Press, London.
- Young, J.Z. **Life of mammals**. Oxford University Press, London.
- Colbert, E.H. **Evolution of the Vertebrates**. John Wiley and Sons Inc., New York.
- Kent, C.J. **Comparative Anatomy of Vertebrates**.
- Wolstenholmf, E.W. and Knight, J. (Ed.) **Taste and Smell in Vertebrates**. J & A Churchill, London.
- Walters. H.A. and Sayles. L.D. **Biology of Vertebrates**. Macmillon & Co., New York.
- Waterman, A.J. **Chordata Structure and Function**. Macmillon Co., New York.
- Montagna, W. **Comparative Anatomy**. Clarendon Press, Oxford.
- Weichert, C.K. and Presch, W. **Elements of Chordate Anatomy**. 4<sup>th</sup> edn. McGraw Hill Book Co., New York.

## **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 potency 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 & pluripotency
18. Embryonic stem cells, chord-blood cells & their significance
19. Hemopoietic stem cells, formation of blood cells
20. Connective tissue cell family

### **Suggested Readings:**

Gilbert, S.F. **Developmental Biology**. Sinauer Associated Inc., Massachusetts.  
Ethan Bier. **The Cold Spring**. The Cold Spring Harbor Laboratory Press, New York.  
Balinsky, B.I. **Introduction to Embryology**. Saunders, Philadelphia.  
Berril, N.J. and Karp, G. **Development Biology**. McGraw Hill, New York.  
Davidson, E.H. **Gene Activity During Early Development**. Academic press, New York.

**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, *Hemidactylus 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 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 ( <i>Hardmania</i> , <i>Amphioxus</i> 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. <i>Viva voce</i>	10
7. Practical record	10

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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

## **ZOOL. 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. Bioluminescence 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:**

- Brown, M.E. **The Physiology of Fishes, Vol. I & II.** Academic Press, New York.
- Lagler, K.F. Bardach, J.E., Miller, R.R. and Passino, D.R.M. **Ichthyology.** John Wiley & Sons, New York
- Hoar and Randall. **Fish Physiology Vol.1-16.** Academic Press, New York.
- Nikolsky, G.V. **The Ecology of Fishes.** Academic Press, New York.

**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 <i>Wallago / Mystus / Labeo / Torpedo</i>	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

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TOTAL MARKS	100
DURATION (HOURS)	06

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## **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 foot printing
12. General idea of DNA micro-array, DNA chips and Affymetrix.

#### UNIT IV

13. Stem cells: Types, culture and applications
14. Methods in analysis of gene expression-I: Transformation, transfections and mammalian expression vectors
15. Methods in gene analysis-II: General idea of site directed mutagenesis, Linker scanning mutations analysis and Reporter assay
16. Recombinant DNA technology: Preparation 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. Secretory pathways and translocation of secretory 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
14. Cell Signaling: Intracellular & cell surface receptors, second messenger & signaling through G-protein coupled receptors (PKA, PKC)
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:**

De Robertis and De Robertis. **Cell and Molecular Biology**. Lea and Febiger.

Watson, Hopkins, Roberts, Steitz, Weiner. **Molecular Biology of the Gene**. The Benjamin/Cummings Publishing Company Inc.

Bruce Alberts, Bray, Lewis, Raff, Roberts, Watson. **Molecular Biology of the Cell**. Garland Publishing Inc.

P. K. Gupta. **Molecular Cell Biology**. Rastogi Publications.

Watson, Gilman, Witkowski, Zoller. **Recombinant DNA**. Scientific American Books

Gerald Karp. **Cell Biology**.

Lewin B. **Genes XI**.

King, **Cell Biology**.

Daniel L. Hartl, Elizabeth W. Jones. **Genetics-Principles and Analysis**. Jones and Bartlett Publishers.  
Lodish, Berk, Zipursky, Matsudaira, Baltimore, Darnell. **Molecular Cell Biology**. W. H. Freeman and Company.

J. Travers. **Immunology**. Current Biology Limited.

Kuby. **Immunology**. W. H. Freeman and Company.

Gardner, Simmons, Snustad. **Principles of Genetics**. John Wiley and Sons Inc.

S. M. Brown. **Bioinformatics**. Eaton Publishing.

Pelczar, Chan, Kreig. **Microbiology**. Tata McGraw Hill

Prescott, Harley, Klein. **Microbiology**. Wm C. Brown Publishers

T. A. Brown. **Gene Cloning**.

T. A. Brown, **Genomes**.

Ausbel, Brent, Kingston, Moore, Seidman, Smith, Struhl. **Current Protocols in Molecular Biology**, Vol I-II.  
Green Publishing Associates.

Bisen: Laboratory protocols in applied lifesciences, CRC Press

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

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TOTAL MARKS	100
DURATION (HOURS)	06

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**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**

1. Dissection of endocrine glands in vertebrate/ invertebrate	10
2. Estimation of hormones in blood	10
3. Quantitative estimation of proteins/cholesterol/ blood sugar level	10
4. Microtomy of endocrine material	10
5. Separation of plasma proteins using electrophoresis	10
6. Study of Comparative structure of endocrine glands	10
7. Spotting (slides – 2, molecular structure of hormones – 2, electron micrograph – 2)	20
8. <i>Viva voce</i>	10
9. Practical record	10
<b>TOTAL MARKS</b>	<b>100</b>
<b>DURATION (HOURS)</b>	<b>06</b>

## **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 Malpighian 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. <i>Viva voce</i>	10
7. Practical record	10
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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 Weberian 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 functions 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 (fossilized & Recent).  
Francis day Vol I & II Fishes of India.  
C.B.LShrivastava, Fish Biology.  
K.S.Mishra: An aid to classification of Fishes.  
Gopalji Shrivastava: Indian of fishes of U.P.& Bihar.  
B.Qurashi: Identification of fishes.  
W.D.Rusell: Aquatic Productivity.  
A.J.K.Mainan: Identification of fishes.  
K.F.Lagler: Ichthyology.  
N.R.Rao: An Introduction of fishes.  
J.F.Norman: An History of fishes.  
S.S.Khanna: An Introduction of fishes.  
R.L.Rath: Fresh water Aquaculture.

H.R.Singh: Advance in fish Biodiversity.

H.D.Kumar: Sustainibility & Management of Aquaculture & Fisheries.

Arugun & Natarajan: Fresh water Aquaculture.

Arugun & Natarajan: Santanu-Costal Aquaculture.

R.Sanatham: A manual of fresh water Aquaculture.

## **LIST OF PRACTICAL EXERCISES FOR LABORATORY COURSE**

### **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**

1. Dissection with display and diagram	20
2. Fish physiological exercise related to digestion respiration osmoregulation and colour change	10
3. Minor dissection with display and diagram	10
4. Mounting/skeletal preparation 02	10
5. Spotting (museum specimens-3, histological slides-3, bones-3)	30
6. <i>Viva voce</i>	10
7. Practical record	10

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TOTAL MARKS	100
DURATION (HOURS)	06

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## **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

13. Reproductive behaviour. Evolution of sex and reproductive strategies, mating systems, courtship, sexual selection. parental care
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
16. Social Organization in primates.

#### 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:**

- Eibl-Eibesfeldt, I.: Ethology. The biology of Behaviour. Holt, Rinehart & Winston, New York
- Gould, J.L.: The mechanism and Evolution of Behaviour.
- Kerbs, J.R. and N.B. davies: Behaviourable Ecology. Blackwell, Oxford, U.K.
- Hinde, R.A.: Animal Behaviour: A Synthesis of Ethology and Comparative Psychology. McGraw Hill, New York.
- Alcock, J.: Animal Behaviour: An Evolutionary approach. Sinauer Assoc. Sunderland, Massachsets, USA.

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

Kandel, ER, Schwartz, JH. and Jessell, T.M.: Principles of Neural science. McGraw Hill, New York.

Brown AG.: Nerve cells and Nervous systems. Narosa Publishing house, Delhi.

Mishra.: Clinical Neuro-physiology. Churchill Livingstone

## **ZOOL. 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:**

Chandler, A.C. and C.P. Read. **Introduction to Parasitology**. Wiley Eastern, New Delhi.

Croll, N.A. **Ecology of Parasites**. Heinemann, London.

Dogiel, V.A. **General Parasitology**. Oliver and Boyd, Edinburgh, London.

Jones, A.W. **Introduction to Parasitology**. Addison-Wesley Reading, Mass

Kuby, **Immunology**. W.H. Freeman, USA.

Paul, W. **Fundamentals of Immunology**.

Roitt, I.M. **Essential Immunology**. ELBS edition.

**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**

1.Immunological experiments (immunodiffusion / immunoelectrophoresis)	10
2.Immunocytochemistry / ELISA	10
3.Experiments on animal behaviour (02)	20
4.Identification & comments upon 8 spots (parasitic adaptations in protozoans, helminthes & other animals, parasitic invasion, host – parasite interaction & animal behaviour)	30
5.Blood film preparation and identification of cells	10
6.Viva voce	10
7.Practical record	10
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<b>TOTAL MARKS</b>	<b>100</b>

## **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

## **ZOOL. 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:**

- Brown, M.E. **The Physiology of Fishes Vol. I & II.** Academic Press.
- Lagler, K.F., J.E. Bardach, R.R. Miller and D.R.M. Passino. **Ichthyology.** John Wiley & Sons, New York.
- Hoar and Randall. **Fish Physiology Vol.1-16.** Academic Press.
- Nikolsky, G.V. **The Ecology of Fishes.** Academic Press.
- Day, F. **The Fishes of India. Vol. I & II.** William Dawson & Sons Ltd. London.
- Khanna, S.S and Singh H.R. **Fish biology and fisheries.** Narendra Pub. House Delhi
- Biswas, S.P. **Fundamental of Ichthyology.** Narendra Pub. House Delhi.
- Srivastava, C.B.L. **Fishery science and fisheries** Kitab Mahal.



- Gary, M.R. and Sam, R.P. **Fundamentals of Aquatic Toxicology**. Hemisphere Pub. Corp.  
 Sharma, B.K. and Kaur, H. **Water Pollution** Goel Pub. House.  
 Santhanam, R. Ramanathan, N. and Jegatheesan, G. **Coastal Aquaculture in India** CBS Pub.  
 Hynes, H.B.N. **The Ecology of Running waters** Liverpool Uni. Press  
 Chakraborty, C. and Sadhu, A.K. **Biology Hatchery and Culture technology of Tiger prawn and giant freshwater prawn** Daya Pub. House, Delhi  
 Saxena, A. **Text book of Crustacea** Discovery Pub. House.  
 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 hypohysation, 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

1. Identification of freshwater prawns, fishes, frogs, turtles & crocodiles up to species with biometric data	20
2. Experiments on carp breeding through hypohysation / cultures of plankton / identification fish fries, fingerlings, post-larvae of prawns	10
3. Identification & comment upon common weeds, predator fishes, insects, other aquatic organisms harmful to fishes, nets, gears, crafts, sampling tools and apparatuses	30
4. Statistical procedures in fishery science / length-weight relationship / condition factor / estimation of fecundity	10
5. <i>Viva voce</i>	10
6. Practical record, visit / survey report / materials, charts, models, specimens	10
7. Seminar	10
<b>TOTAL MARKS</b>	<b>100</b>

## **B. CELL BIOLOGY**

### **ZOOL. 403 (B): NEUROBIOLOGY AND AGEING**

#### Unit-I

1. Gross organization of the nervous system.
2. Neuron: structure, types and organization.
3. Neuronal membrane and action potential.
4. Axons and dendrites

#### Unit-II

5. Synaptic transmission and cellular signaling.
6. Neurotransmitters.
7. Intercellular and intracellular signaling.
8. Role of G-protein and second messenger in cellular signaling.
9. Neurotransmitter and disorders of the basal ganglia.

#### Unit-III

10. Glial cells: Types, structure and functions.
11. Astrocytes.
12. Oligodendrocytes and Schwann cells
13. Microglia.

#### 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:**

1. Kandel, **Principles of neural science** (5<sup>th</sup> Edition), McGraw Hill, 2012
2. Shepherd, **Neurobiology** (3<sup>rd</sup> Edition), Oxford University Press, 1994
3. Bear, **Neuroscience: Exploring the brain** (3<sup>rd</sup> Edition), Lippincott, 2007
4. Siegel, **Basic neurochemistry: molecular, cellular and medical aspect**, (7<sup>th</sup> Edition), Academic press, 2006
5. Squire, **Fundamental neuroscience** (4<sup>th</sup> Edition), Academic Press Inc , 2012

**ZOOL. 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
12. Environmental modulation of gene activity (stress response): stress genes and stress proteins

## 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 homeoboxes

**Suggested Readings:**

Robertis, De and De Robertis. **Cell and Molecular Biology**. Lea and Febiger.  
Watson, Hopkins, Roberts, Steitz and Weiner. **Molecular Biology of the Gene**. The Benjamin/Cummings Publishing Company Inc.

Bruce Alberts, Bray, Lewis, Raff, Roberts, Watson. **Molecular Biology of the Cell**. Garland Publishing Inc.

Watson, Gilman, Witkowski, Zoller. **Recombinant DNA**. Scientific American Books.

Karp, Gerald **Cell Biology**.

Lewin, B. **Genes VII**

King. **Cell Biology**.

Daniel, L., Hartl, Elizabeth W. Jones. **Genetics-Principles and Analysis**. Jones and Bartlett Publishers.

Lodish, Berk, Zipursky, Matsudaira, Baltimore, Darnell. **Molecular Cell Biology**. W. H. Freeman and Company.

Suzuki, Griffiths, Miller, Lewontin. **An Introduction to Genetic Analysis**. W. H. Freeman and Company.

Travers, J. **Immunology**. Current Biology Limited.

Kuby, **Immunology**. W. H. Freeman and Company.

Roitt, Male, Snustad, **Immunology**.

Gardner, Simmons, Snustad. **Principles of Genetics**. John Wiley and Sons Inc.

**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 heat shock puffs and gene activity in chironomus/ *Drosophila*.
- Study of monohybrid and dihybrid crosses/sex linkage in *Drosophila*.
- Study of development (homeotic) and other phenotypic Mutants of *Drospphila*.
- Methods in immunodetection: Western blotting, immunofluorescence, immunocytology, etc.

**SCHEME OF PRACTICAL EXAMINATION**

1. Study of mitotic/meiotic / polytene chromosomes/heat shock puffs gene activity	20
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. <i>Viva voce</i>	10
6. Practical record	10
7. Seminar	10

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<b>TOTAL MARKS</b>	<b>100</b>
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## **C. ENDOCRINOLOGY**

### **ZOOL. 403 (C); MALE REPRODUCTIVE ENDOCRINOLOGY**

#### UNIT I

1. Differentiation of the testes and male genital ducts
2. Histology of testes, epididymis, vasdeferens 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 parapatial 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:**

Turner, C.D. and J.T. Bagnara. **General Endocrinology**. W.B. Saunders.

Bentley, P.J. **Comparative Vertebrate Endocrinology**. Cambridge University Press, Cambridge, U.K.

Hadley, M.E. Endocrinology.

Greep, R.O. Hand book of Physiology Vol.6: Male Reproduction. American Physiological Society, Washington.

Greep, R.O. Hand book of Physiology Vol.7: Female Reproduction. American Physiological Society, Washington.

**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.	<i>Viva voce</i>	10
7.	Practical record	10
8.	Seminar	10

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TOTAL MARKS	100
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## **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) *Chilo* (c) *Pyrilla* (d) *Aleurolobus*
9. Structure, life history, significance, nature of damage and control methods of following cotton pests: (a) *Sylepta* (b) *Erias* (c) *Pectinophara* (d) *Dysdercus*

**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) *Sitotrua* (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.
16. Housefly: A human health hazard and its 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**

1. Richards, O.W. and R.G. Davies. **Imm's Text book of Entomology**. Methuen and Co., London.
2. Snodgrass, R.E. **Principles of Insect Morphology**. Tata MacGraw Hill,s Bombay.
3. Fox, R.M. and J.W. Fox. **Introduction to Comparative Entomology**. Reinhold Publishing Corporation, New York.
4. Chapman, R.F. **The Insects – Structure and Function**. ELBS, London.
5. Nayar, K.K., T.N. Ananthakrishnan and B.V. David. **General and Applied Entomology**. Tata MacGraw Hill, New Delhi.
6. Smith, K.G.V. **Insects and other Arthropods of Medical Importance**.
7. Ross, H.H. **A Text book of Entomology**. John Wiley & Sons, New York.

**LIST OF PRACTICAL EXERCISES****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. <i>Viva voce</i>	10
7. Practical record including collection & display	10
8. Seminar	10

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Total Marks	100
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## **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

## **ZOOL. 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:**

Brown, M.E. **The Physiology of Fishes, Vol. I & II.** Academic Press, New York.  
 Lagler, K.F. Bardach, J.E., Miller, R.R. and Passino, D.R.M. **Ichthyology.** John Wiley & Sons, New York  
 Hoar and Randall. **Fish Physiology Vol.1-16.** Academic Press, New York.  
 Nikolsky, G.V. **The Ecology of Fishes.** Academic Press, New York.

**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**

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