



**MAHARAJA SURAJMAL BRIJ UNIVERSITY,  
BHARATPUR**

**SYLLABUS**

**M.Sc. ZOOLOGY (P &F)  
(ANNUAL SCHEME)**

  
अकादमिक प्रभारी  
महाराजा सूरजमल बृज विश्वविद्यालय  
भरतपुर (राज.)

**M.S. BRIJ UNIVERSITY, BHARATPUR**

**SCHEME OF EXAMINATION**

**M.Sc. ZOOLOGY**

**(Annual Scheme)**




Each Theory Paper	3 hrs. duration	100 Marks
Practical (Two days)	5 hrs. duration	300 marks

1. The Number of papers and the maximum marks for each paper and practical shall be shown in the syllabus for the subject concerned. It will be necessary for a candidate to pass in the theory as well as in practical part of a subject/paper separately.
2. A candidate for a pass at each of the previous and the final Examinations shall be required to obtain (i) at least 36% marks in the aggregate of all the papers prescribed for the examination and (ii) at least 36% marks in practical (s) wherever prescribed at the examination, provided that if a candidate fails to secure at least 25% marks in each individual paper at the examination and also in the dissertation/ Survey report/ field work(if any), wherever not withstanding his having obtained the minimum percentage of marks required in the aggregate for that examination. No division will be awarded at the previous examination. Division shall be awarded at the end of the final examination on the combined marks obtained at the previous and the final examination taken together.
3. If a candidate clears any paper(s) Practical(s) Prescribed at the previous and/or final examination after a continuous period of three years, then for the purpose of working his division the minimum pass of marks only viz. 25% (36% in case of practical) shall be taken into account in respect of such papers/practicals.

**M.Sc. PREVIOUS (ANNUAL SCHEME)**

- Paper - I Biosystematics and Taxonomy
- Paper - II Structure & Function of Invertebrates
- Paper - III Molecular biology and Biotechnology

  
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Paper - IV General Physiology

Paper - V Biochemistry

Paper - VI Population Genetics and Statistical methods.

(Laboratory Exercises Seminar Demonstration)

Practical Day First and Day Second

300 Marks

**Note:-** In M.Sc. Zoology Previous Examination the theory papers will have the following pattern.

Question papers will have 5 (five) questions in all having equal marks

- (i) Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
- (ii) Question numbers 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
- (iii) Question numbers 4 and 5 will be long answer type questions with internal choice.

### **Paper- 1 : BIOSYSTEMATICS AND TAXONOMY**

**3 Hours duration**

**Max. Marks: 100**

**Periods : 80**

Theory paper will have the following pattern.

Question paper will have 5 (five) question, having 20 marks each ...

- (i) Question number will be compulsory and will have 20 very short answer question of 1 marks each.
- (ii) Question numbers 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
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1. Definition and basic concept of biosystematics and taxonomy

1.1 Historical resume of Systematics.

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- 1.2 Importance and applications of biosystematics in biology.
- 1.3 Manual basis of histo-systematics-different attributes.
2. Trends in biosystematics: Concept of different conventional and newer aspects
  - 2.1 Chemotaxonomy
  - 2.2 Cytotaxonomy
  - 2.3 Molecular taxonomy
3. Molecular perspective on the conservation of diversity
  - 3.1 Diversity and ecosystem process: Theory, achievements and future directions.
4. Dimensions of speciation and taxonomy characters
  - 4.1 Dimensions of speciation - Types of lineage changes: production of additional lineage.
  - 4.2 Mechanisms of speciation, panmictic and apotmictic species.
  - 4.3 Species concept and species category. Different species concepts subspecies and other infra-specific categories.
  - 4.4 Theories of biological classification: hierarchy of catagories.
  - 4.5 Taxonomic characters of different kinds, origin of reproductive isolation and biological mechanism of genetic incompatibility, Haldane's rule.
5. Procedure keys in taxonomy.x
  - 5.1 Taxonomic procedures: Taxonomic collections, preservation, correct process of identification.
  - 5.2 Taxonomic keys: Different kinds of taxonomic keys, their merits and demerits.
  - 5.3 Systematic publications and different kinds of publications.
  - 5.4 Process of typification and different Zoological types.
  - 5.5 International Code of Zoological Nomenclature (ICZN) and its operative principles, interpretation and application of important rules. Zoological nomenclature, formation of Scientific names of various texa.
6. Evaluation of biodiversity indices
  - 6.1 Shannon-Weinner index, dominance index.
  - 6.2 Similarity and dissimilarity index.
  - 6.3 Association index

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### Suggested Reading Material (All latest editions)

1. Kato, M. The Biology of Biodiversity, Springer.
2. Avise, J.C, Molecular Markers, Natural History and Evolution Chapman & Hall, New York.
3. Wilson, E.O, Biodiversity Academic Press, Washington.
4. Simpson, G.G., Principle of Animal Taxonomy. Oxford, IBH Publishing Company.
5. Mayer, E., Principles of Systematic Zoology, McGraw Hill Book Company, New York.
6. Wilson, E.O., The Diversity of Life. W.W. Northern & Company.
7. Tikadar, B.K., Threatened Animals of India, ZSI Publication, Calcutta.
8. Trigunayat, M.M and Kritika Trigunayat. Introductory Biosystematics & Taxonomy Scientific Publishers, Jodhpur.
9. Southwood, T.R.E. Ecological methods (3rd edition). Blackwell Scientific Publishers.

### PAPER- II : STRUCTURE & FUNCTION OF INVERTEBRATES

**3 Hours duration**

**Max. Marks-100**

**Periods : 80**

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- (iii) Question numbers 4 and 5 will be long answer type questions with internal choice.

#### 1. Organization of Coelom

1.1 Acoelomates

1.2 Pseudocoelomates

1.3 Coelomates: Protostomia and Deutersotomia.

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2. Locomotion
  - 2.1 Flagellar and ciliary movement in Protozoa.
  - 2.2 Hydrostatic movement in Coelenterata, Annelida and Echinodermata.
3. Nutrition and Digestion
  - 3.1 Patterns of feeding and digestion in lower Metazoa.
  - 3.2 Filter feeding in Polychaeta, Mollusca and Echinodermata.
4. Respiration
  - 4.1 Organs of respiration: Gills, lungs and trachea.
  - 4.2 Respiratory pigments.
  - 4.3 Mechanism of respiration
5. Excretion
  - 5.1 Organs of excretion: Coelom, Coelomoducts, Nephridia and Malpighian tubules.
  - 5.2 Mechanisms of excretion.
  - 5.3 Excretion and Osmoregulation
6. Nervous System
  - 6.1 Primitive nervous system: Coelenterata and Echinodermata.
  - 6.2 Advanced Nervous system: Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda)
  - 6.3 Trends in neural evolution
7. Invertebrate larvae
  - 7.1 Larval forms of free-living invertebrates
  - 7.2 Larval forms of parasites
  - 7.3 Strategies and evolutionary significance of larval forms
8. Minor Phyla
  - 8.1 Concept and significance (Mesozoa, Ctenophora, Rhyncocoela, Protostomes, Deuterostomes)
  - 8.2 Organization and general characters.

### Suggested Reading Material

1. Hyman, L.H. The invertebrates, vol.I, Protozoa through Ctenophora, McGraw Hill Company, New York.
2. Hyman, L.H., The Invertebrates, vol.II, Protozoa through Ctenophora, McGraw Hill Company, New York.

3. Hyman, L.H., The Invertebrates, smaller coelomate Groups, vol.,5, McGraw Hill Company, New York.
4. Hyman, L.H., The Invertebrates, Vol.8, McGraw Hill Company, New York.
5. Barington, E.J.W., Invertebrate Structure and Function. Thomas Nelson and Sons Ltd. London.
6. Barnes, R.D., Invertebrate Zoology, W.B., Saunders Co., Philadelphia.
7. Russel-Hunter, W.D., A Biology of Higher Invertebrates, Mc Millan Company Ltd. London.
8. Cad, G.P. Animal Parasitism, Prentice Hall Inc., New Jersey.
9. Sedwick, A. Student Text Book of Zoology, Vol I, II and III, Central Book Depot, Allahabad.
10. Parker, T.J., Haswell, W.A., Text Book of Zoology, MacMillan Co., London.

### PAPER-III; MOLECULAR BIOLOGY & BIOTECHNOLOGY

**Duration: 3 Hours**

**Max. Marks- 100**

**Periods : 80**

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- (iii) Question numbers 4 and 5 will be long answer type questions with internal choice.

#### 1. DNA replication

1.1 Prokaryotic and eukaryotic DNA replication

1.2 Mechanics of DNA replication

1.3 Enzymes and accessory proteins involved in DNA replication.



#### 2. Transcription

2.1 Prokaryotic Transcription

2.2 Eukaryotic transcription

2.3 RNA polymerases

  
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- 2.4 General and specific transcription factors
- 2.5 Regulatory elements and mechanisms of transcription regulation
- 2.6 Transcription termination
- 2.7 Transcriptional and post-transcriptional gene splicing
3. Post-transcriptional modifications in RNA
  - 3.1 5'- Cap formation
  - 3.2 End processing and polyadenylation
  - 3.3 Splicing, editing
  - 3.4 Nuclear export of mRNA
  - 3.5 RNA Stability
4. Translation
  - 4.1 Genetic code
  - 4.2 Prokaryotic and eukaryotic translation
  - 4.3 Translation machinery
  - 4.4 Mechanisms of initiation, elongation and termination
  - 4.5 Regulation of translation
  - 4.6 Co-and post-translation modifications of proteins.
5. Recombination and repair
  - 5.1 Holiday junction, gene targeting, gene disruption
  - 5.2 FLP/FRT and Crelox recombination
  - 5.3 RecA and other recombinases
  - 5.4 DNA repair mechanisms
6. Molecular mapping of genome
  - 6.1 Genetic and physical maps
  - 6.2 Physical mapping and map-based cloning
  - 6.3 Southern and fluorescence, in-situ hybridization for genome analysis
  - 6.4 Molecular markers in genome analysis, RFLP, RAPD and AFLD analysis
  - 6.5 Application of RPLP in forensic, disease prognosis genetic counselling, pedigree varietal analysis. Animal tracking and poaching germplasm maintenance and taxonomy.
7. Transgenic animals and Knock outs
  - 7.1 Production
  - 7.2 Applications
  - 7.3 Embryonic stem cells

  
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- 7.4 Care and breeding of experimental animals including bioethics
8. Assisted reproduction technologies
- 8.1 Embryo sexing and cloning
- 8.2 Screening for genetic disorders
- 8.3 ICSI, GIFT etc.
- 8.4 Cloning of animals by nuclear transfer

### Suggesting Reading Material

1. Watson, J.D., Hopkins, N.H., Roberts, J.W., Steiz, J.A., Weinef, A.M.; Molecular Biology of Gene. The Benjamin Cummings Pub Co.: Inc., California.
2. Darnell, J., Lodish, H. and Baltimore, D; Molecular Cell Biology, Scientific American Books, Inc., USA.
3. Albert, B., Bray, D.D., Lewis, J., Rafif M., Roberts, K, Walson, J.D., Molecular Biology of the cell. Garland Publishing company, Inc., New York.
4. Benjamin, Lewin, Gene VIII, Oxford University Press, U.K.
5. Meyers, R.A. (ed.), Molecular Biology and Biotechnology. A Comprehensive Desk Reference. VCH Publishers, Inc, New York.
6. Sambrook, J., Fritsch, E.f. and Maniatis, T.; Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, New York.
7. Dabre, P.D., Introduction to Practical Molecular Biology, John Wiley & Sons Ltd., New York.
8. Brown, T.A. (Ed.), Molecular Biology Labfax, Vol.I, Bio Scientific Publishers Ltd. Oxford.
9. Karp, G., Cell and Molecular Biology, Concepts and Experiments, John Wiley & Sons, Inc, New York.
10. Botstein, D. Decoding the language of Genetics. Cold spring harbor Laboratory Press.
11. Tropp. Molecular Biology, Genes to Proteins 4/e. Jones Bartlett (Viva Books)
12. Krebs, Goldstein & Kilpatrik. Lewin's Genes XI. Viva Books Pvt. Ltd.

  
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## PAPER - IV: GENERAL PHYSIOLOGY

**Duration: 3 Hours**

**Max. Marks: 100**

**Periods: 80**

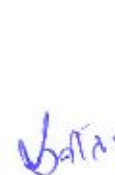



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1. Thermoregulation and Cold Tolerance
    - 1.1 Basic principles of metabolism
    - 1.2 Heat balance and exchange
    - 1.3 Endotherms V/s Ectotherms
    - 1.4 Counter-current heat exchanger
    - 1.5 Torpor, hibernation and aestivation
    - 1.6 Adaptations to very cold environments Ionic and Osmotic Balance.
  2. Ionic and osmotic balance
    - 2.1 Osmoregulation V/s Osmocon forming
    - 2.2 Osmoregulation in aquatic and terrestrial, environments
    - 2.3 Kidney function and diversity
    - 2.4 Other osmoregulatory organs
    - 2.5 Nitrogenous waste excretion
  3. Gas Exchange and Acid-base Balance
    - 3.1 Oxygen and Carbon dioxide transport in blood
    - 3.2 The role of hemoglobin
    - 3.3 Responses to altitude and hypoxia
    - 3.4 Swim bladder inflation in fish
    - 3.5 Regulation of body pH
    - 3.6 Gas transfer in air and water; gas exchanger design and function

  
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4. Muscle Function and Movement
  - 4.1 Anatomy of muscle
  - 4.2 Regulation of contraction
  - 4.3 Excitation-contraction coupling
  - 4.4 Molecular theory of muscle contraction
5. Nervous System
  - 5.1 Anatomy of nervous system
  - 5.2 Neurons and membrane excitation
  - 5.3 Electrochemical potentials
  - 5.4 Action potentials
  - 5.5 Transmission between neurons
  - 5.6 Synapses and neurotransmitters
  - 5.7 Memory and learning
6. Sensory Transduction
  - 6.1 Sensing the environment
  - 6.2 Auditory receptors
  - 6.3 Chemoreceptors; Taste and smell, homing in salmon
  - 6.4 Mechanoreceptors: Tactile Systems and escape responses
  - 6.5 Vision and photoreception
  - 6.6 Thermoreception and infrared detection: Prey detection in snakes.
  - 6.7 Echolocation in bats
7. Digestion and Metabolism
  - 7.1 Nutritional uptake and distribution
  - 7.2 Effects of starvation
8. Stress Biology
  - 8.1 Basic concept of environmental stress and strain concept of elastic and plastic strain; stress resistance, stress avoidance and stress tolerance.
  - 8.2 Adaptation, acclimation and acclimatization
  - 8.3 Concept of homeostasis
  - 8.4 Physiological response to oxygen deficient stress.
  - 8.5 Physiological response to body exercise
  - 8.6 Meditation, yoga and their effects.
9. Endocrinology
  - 9.1 Aims and Scope of endocrinology
    - 9.1.1 Discovery of hormones.


- 9.1.2 Hormones as messengers.
- 9.1.3 Classification of hormones
  - 9.2 Phylogeny of endocrine glands (Pituitary, pancreas, adrenal, thyroid, etc.)
  - 9.3 Ontogeny of endocrine glands.
  - 9.4 Neuroendocrine system and neurosecretion
  - 9.5 General principles, structure and hormone action
  - 9.6 Hormones, growth and development
  - 9.7 Hormones and reproduction.

### Suggested Reading Material

1. Eckert, R.W.H.; Animal Physiology, Mechanisms and Adaptations, Freeman and Company, New York.
2. Fochachka, P.W. and Somero, G.N.; Biochemical Adaptation, Princeton, New Jersey.
3. Hoar, W.S.; General and Comparative Animal Physiology, Prentice Hall of India.
4. Schiemdt Nelsen; Animal Physiology: Adaptation and Environment, Cambridge University Press.
5. Strand F.L., Physiology: A Regulatory Systems Approach, Macmillan Publishing Co., New York.
6. Prosser, C.L.; Environmental and Metabolic Animal Physiology, Wiley-Liss, Inc., New York.
7. Willmer, Stone, P.G. and Johnson, I: Environmental Physiology, Blackwell Sci. Publication, Oxford, U.K.
8. Newell, R.C.(ed.); Adaptation to Environment; Essays on the Physiology of Marine Animals. Butter worths, London, U.K.
9. Townsend, C.R. and Cawlow.P. : Physiological Ecology: An Evolutionary Approach to Resource Use, Blackwell, Sci. Publication, Oxford, U.K.
10. Hill, R.W. Wyse, G.A., Anderson, M.: Animal Physiology, Sinauer Associates, Inc, Publishers, Sunderland, USA.
11. Vander.A.J. Sherman J.H. Luciano D.S., Human Physiology McGraw-Hill Publishing Company, New York.
12. Dejours, P.L. Bolis, L.Taylor, C.R., Weibel, E.R. (eds.), Comparative Physiology: Life in water or Land, Liviana Press, Padova, Italy..

  
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13. Johnson, I.A., Bennett, A.F. (eds.), Animals and Temperature, Phenotypic and Evolutionary Adaptations. Cambridge University Press. Cambridge, U.K.
14. Louw G.N. Physiological Animal Ecology, Harlow, U.K.
15. Barrington, E.J.W., General and Comparative Endocrinology Clarendon Press, Oxford.
16. Williams, R.H., Text Book of Endocrinology, W.B. Saunders.
17. Martin, C.R. Endocrine Physiology, Oxford University Press.
18. Gorbman, A., Dickhoff, W.W., Vigna, S.R., Cvlark, H.B., Ralpls, C.L. Comparative Endocrinology, Wiley- Interscience Publication, New York.

### PAPER- V: BIOCHEMISTRY

**Duration: 3 Hours**

**Max. Marks: 100**

**Periods: 80**

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- (iii) Question numbers 4 and 5 will be long answer type questions with internal choice.

1. Covalent properties of Proteins
  - 1.1 Structure and Chemistry of amino acids
  - 1.2 protein sequencing
  - 1.3 Peptide Synthesis
  - 1.4 Covalent modifications
  - 1.5 Protein size and composition
  - 1.6 Protein splicing
2. Protein secondary and tertiary structure
  - 2.1 Protein Tertiary structure and folding patterns
  - 2.2 Common tertiary structural motifs.

  
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- 2.3 Role of packing constraints in tertiary structure patterns.
- 2.4 Divergent vs. convergent evolution of similar structure.
- 3 Globular and fibrous proteins.
  - 3.1 Water and the hydrophobic effect.
  - 3.2 Tertiary and quaternary effect.
  - 3.3 Motifs in globular proteins.
  - 3.4 Properties of protein interiors and surfaces.
  - 3.5 Fibrous proteins.
  - 3.6 Structure of bone.
- 4 Protein folding and thermodynamics
  - 4.1 Protein folding and dynamics.
  - 4.2 Folding overview: The Levinthal Paradox.
  - 4.3 Condensation and molten globules.
  - 4.4 Ramchandaran plots and amino acid propensities.
  - 4.5 Catalysis and assistance.
  - 4.6 Amino acid sequence variation and membrane protein folding.
  - 4.7 Chaperonin-assisted protein folding.
- 5 Allostery (Hemoglobin), Myoglobin structure and oxygen binding.
  - 5.1 Hemoglobin subunits cooperativity, the Hill coefficient.
  - 5.2 Quaternary Structure changes and Sickle cell and other molecular diseases.
- 6 Fats
  - 6.1 Fatty acids: Structure, nomenclature, acyl glycerols, phospholipids, sphingolipids, glycolipids, lipoproteins.
  - 6.2 Terpenoids and sterols: structure, properties and function.
  - 6.3 Function of lipids.
  - 6.4 Signal transducing molecules.
- 7 Vitamins
  - 7.1 Classification, occurrence of fat soluble vitamins.
  - 7.2 Classification, occurrence and biological functions of thiamin, riboflavin, folic acid and B<sub>12</sub>
  - 7.3 Phenolics and alkaloids: structure, biological properties and functions.
- 8 Covalent properties of nucleic acids.
  - 8.1 Modified nucleosides
  - 8.2 Properties of polynucleotides
  - 8.3 Secondary and tertiary structure

  
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- 9 Nucleic acid structure
  - 9.1 Duplex stability.
  - 9.2 Hybridization.
  - 9.3 RNA structure.
  - 9.4 Hairpin and pseudoknot structures, tRNA.
- 10 Nucleic acid structure.
  - 10.1 DNA and RNA helical geometries (A-Z), banding, deformation, triplexes, quadruplexes.
- 11 Nucleic acid analysis. DNA and RNA sequencing, determination of modified nucleotides. Analysis of nucleic acid secondary structure.
- 12 RNA Catalysis
  - 12.1 Chemistry and structure of ribozymes.
  - 12.2 Evolutionary implications.
- 13 Enzyme mechanisms
  - 13.1 Principles of enzyme catalysis.
  - 13.2 Proteases and polymerases, other example.
  - 13.3 Coenzymes and Cofactors.
- 14 Inborn errors of metabolism.

### Biochemistry

1. Alberts R.H. Frey P.A. and Jencks W.P. Biochemistry Jones, & Bartlett Publisher, Boston/London. 1992.
2. Deb A.C. Fundamentals of Biochemistry, New Book Agency Pvt. Ltd. Calcutta, 2006.
3. Nelson D.L. and Cox M.M. Lehninger Principles of Biochemistry, MacMillan/Worth Publishers, 2001.
4. Stryer L. Biochemistry. W.H. Freeman and Co. New York, 2001.
5. Voet D. Voet J.G. and Pratt. C.W. Fundamentals of Biochemistry, Johan Wiley and Sons Inc., New York, 1999.
6. Wilson K. and Walker.J. Principles and Techniques of Practical Biochemistry Cambridge University Press, Cambridge, 1994
7. Zubay G.L. Parson W.W. and Vence D.E. Principles of Biochemistry. Wm.C.Brown Publishers, Oxford, England, 1995.
8. Harper's Biochemistry by Murray R.K., Granner D.K., Mays P.A., Radwell V.W. McGraw Hill Publication, 2000.

  
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9. Mathews, C.K., Van Holde, K.E., Ahern, K.G., Biochemistry, Pearson Education Pvt. Ltd. Delhi, India, 2003.
10. Horton, H.R., Morson, L.A. Serimgeour, K.G., Perry, M.D., Rawn, J.D., Principles of Biochemistry, Pearson Education, International, 2006.
11. McKee, T., McKee J.R., Biochemistry (The Molecular Basis of Life) McGraw Hill company, Inc.
12. Elliott, W.H. and Elliott, D.C. Biochemistry and Molecular Biology, Oxford University Press, Oxford, 2003.
13. Champe, P.C., Harvey, R.A.; Lippincott's Illustrated Reviews: Biochemistry, Lippincott Williams & Wilkins, Philadelphia.

### PAPER-VI:

### POPULATION GENETICS AND STATISTICAL METHODS

**Duration: 3Hours**

**Max.Marks : 100**

**Periods: 80**

**Note:-** In M.Sc. Zoology Previous Examination the theory paper will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks

- (i) Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
- (ii) Question numbers 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
- (iii) Question numbers 4 and 5 will be long answer type questions with internal choice.

#### Unit-I

#### Statistical Methods

1. Definition and application of Biostatistics.
2. Principles and practice of statistical methods in biological research, samples and populations
  - 2.1 Basic statistics-average.
  - 2.2 Statistics of dispersion, coefficient of variation.

  
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- 2.3 Standard errors: Confidence limits.
- 2.4 Probability distributions (binomial, Poisson and normal)
- 2.5 Tests of statistical significance- (Z-test, Students t-test and F-test)
- 2.6 Simple correlation of regression.
- 2.7 Analysis of Variance

## Unit-II: Population Genetics

1. Concepts of evolution and theories of organic evolution with and emphasis on Darwinism, Sexual selection and Zahavi's rule.
2. Neo-Darwinism
  - 2.1 Hardy-Weinberg's law of genetic equilibrium and its applications
  - 2.2 Detailed account of destabilizing forces-
    - (i) Natural selection
    - (ii) Mutation
    - (iii) Genetic drift
    - (iv) Migration
    - (v) Meiotic drive
  - 2.3 Genetic structure of natural populations.
  - 2.4 Phenotypic variation
  - 2.5 Models explaining changes in genetic structure of populations.
  - 2.6 Factors affecting human disease frequency.
3. Molecular population genetics
  - 3.1 Patterns of change in nucleotide and amino acid sequences.
  - 3.2 Ecological significance of molecular variations.
  - 3.3 Emergence of Non-Darwinism-Neutral hypothesis.
4. Genetics of Quantitative traits in populations.
  - 4.1 Analysis of quantitative traits.
  - 4.2 Quantitative traits and natural selection.
  - 4.3 Estimation of heritability.
  - 4.4 Genotype-environment interactions.
  - 4.5 Inbreeding depression and heterosis.
  - 4.6 Molecular analysis of quantitative traits.
  - 4.7 Phenotypic plasticity.

5. Genetics of specifications
  - 5.1 Phylogenetic and biological concept of species.
  - 5.2 Patterns and mechanisms of reproductive isolation.
  - 5.3 Models of specification (allopatric, sympatric, parapatric).
6. Molecular Evolution
  - 6.1 Gene evolution.
  - 6.2 Evolution of gene families, molecular drive.
  - 6.3 Assessment of molecular drive.
  - 6.4 Micro-and macro-evolution.
7. Molecular phylogenetics
  - 7.1 Construction of Phylogenetic trees.
  - 7.2 Phylogenetic inference-distance methods, parsimony methods, maximum likelihood method.
  - 7.3 Immunological techniques.
  - 7.4 Amino acid sequence and phylogeny.
  - 7.5 Nucleic acid phylogeny-DNA-DNA hybridizations, restriction enzyme sites, nucleotide sequence comparisons and homologies.
  - 7.6 Molecular clocks.

#### Suggested Reading Material (Biostatistics).

1. Batschelet, E: Introduction to Mathematics for Life Scientists Springer, Verlag, Berlin.
2. Allen Bluman Elementary Statistics: A brief version 5(ed)
3. Banden, D., Modelling in Behavioural Ecology, Chapman and Hall London, U.K.
4. Sokal R.R. and Rolf, F.J. : Biometry; Freeman, San Francisco.
5. Snedecor, H.W. and Cochran, W.G., Statistical Methods. Affiliated East-West Press, New Delhi.
6. Green, R.H.: Sampling Design and Statistical Methods for Environmental Biologists, John Wiley & Sons, New York.
7. Murray, J.D., Mathematical Biology, Springer-Verlag, Berlin,
8. Bernard Rosner. Fundamentals of Biostatistics
9. Wayne. W. Daniel. Biostatistic: Basic Concept & methodology for health Science. wiley student edition.
10. David L. Strener and Geoffery Norman Biostatistics: The Bare essentials.

### Suggested Reading Material (Population Genetics)

1. Dobzhansky, T., Alaya, F.J., Stebbins, G.L., Valentine, J.M, Genetics and Origin of Species, Surjeet Publication, Delhi.
2. Futuyamma, D.J. Evolutionary Biology, suinuaner Associates, Inc., Massachusetts, U.S.A.
3. Hart, D.L., A Primer of Population Genetics, Suinuaer, Suinuaer Associates, Inc., Massachusetts, U.S.A.
4. Jha, A.P. Genes and Evolution, John Publication, New Delhi.
5. King M., Species Evolution: The Role of Chromosomal Change Cambridge University Press, Cambridge.
6. Merral, D.J., Holt, R. Evolution and Genetics, Rinchart and Winston, Inc.
7. Smita.J.M., Evolutionary Genetics, Oxford University Press, New York.
8. Strikberger, M.W., Evolution, Jones & Barlett Publishers, Boston, London.

### M.S. BRIJ UNIVERSITY, BHARATPUR

#### M.Sc. (Previous) Zoology PRACTICAL EXERCISES

#### I. Study of Anatomy:

##### a. Major:

1. **Leech:** Reproductive, excretory, nervous and haemocoelomic systems.
2. **Crab:** Nervous system.
3. **Scorpion:** Nervous and reproductive systems.
4. **Mollusca:** General anatomy of Aplysia and Nervous systems of Patella. Lamellidens, Mytilus. Sepia and Aplysia.

**Note:** Software on alternatives to dissection can be purchased in Lab Virtual dissection can be substituted. The department can send membership to such software dealers.

##### b. Minor:

5. Cockroach Brain, Proventriculus ganglion, Testis, Salivary gland
6. Book lungs of scorpion
7. (i) Study of Aristotle's lantern of Sea urchin and disarticulated parts of Aristotle's lantern (Through figure Only)  
(ii) Testicular nephridia of Leech.

II. **Museum Specimens:** Identification, classification and distinguishing features of important representatives from various groups (Protozoa to Hemichordata).

III. **Study of Permanent Preparations (Protozoa to Hemichordata):**

Ameba, Entamoeba, Polystomella, Actinophryx, Euglena, Noctiluca, Volvox colony, Trypanosoma, Giardia, Opalina, Nyctotherus, Balantidium, vorticella, Monocystis, Plasmodium, Sycon T.S. and L.S. Gemmule, Obelia colony, Obelia medusa, Aurelia tentaculocytes, T.S. Fasciola hepatica sections through various regions of the body, Hirundinaria body sections through various regions, Daphnia, Cypris, Cyclops, T.S. Peripatus.

**Larva:** Aurelia-planula, Redia, Cercaria, Meta-cercaria, Onchosphere, Cysticercus, Trochophore, Nauplius, Zoea, Mysis, Phyllosoma, Veliger, Glochidium, Bipinnaria. Ophiopluteus, Echinopluteus, Auricularia, Tornaria.

IV. **Biological Chemistry:**

- (i) Identification of protein, Carbohydrate and lipid in various tissues/body fluids/food material.
- (ii) Identification of different kinds of mono-, di- and poly-saccharides in biological and chemical materials.
- (iii) Verification of Beer-Lambert's Law.
- (iv) Quantitative estimation of the following in various tissues:
  - a) Carbohydrates: Glycogen, glucose.
  - b) Proteins: Total Proteins
  - c) Lipids: Phospholipids and cholesterol.
  - d) Nucleic acid: DNA and RNA.
  - e) Enzymes: Acid and alkaline phosphatases.

V. **Physiology:**

- (i) Study of the following with the help of Computer Assisted Learning (CAL) (please see E-pharm programme).
  - A. The effect of K, Ca, acetylcholine and epinephrine on the isolated heart of frog and conclude your data with the graphic representation Computer Assisted Learning (CAL) be included.

  
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- B. The effect of various doses of acetylcholine and Nor-epinephrine on blood pressure, heart rate and respiratory rate of the rabbit.
- C. The effects of Atropine Epinephrine, Ephedrine and Eserine on Rabbit's eyes. Other such exercises can be framed from the E-Phram software.
- (ii) Determination of blood pressure, pulse rate, heart beat and respiration rate.
- (iii) Photometric determination of hemoglobin in blood sample.
- (iv) Determine of MCV, MCH, MCHC and colour index of the given sample of blood.
- (v) Demonstration of the following in blood: clotting time, erythrocyte sedimentation rate, haemolysis, crenation and preparation of haematin crystals.
- (vi) Determination of the urea in urine/blood.
- (vii) Determination of the glucose in urine.
- (viii) Study of digestive enzymes in different parts of the alimentary canal.
- (ix) Demonstration of Blind spot in Human eye.
- VI. Cell & Molecular Biology & Biotechnology:**
- (i) Squash and smear preparations of testis of cockroach and grasshopper, acetoorecin, Fuelgen and Giemsa Staining of these preparations.
- (ii) Study of mitosis in onion root tip.
- (iii) Study of giant Chromosomes in the salivary gland of Chironomus or Drosophila larva.
- (iv) Vital and supravital staining (With neutral red and Janus Green B) of cells of the testis of any insect or mammal to study the mitochondria.
- (v) Chromosome counts in cells of the testis of an insect or mammal or cells of the bone marrow of a mammal.
- (vi) Study of prepared microscopic slides, including those showing various cell types, mitosis, meiosis and giant chromosomes.
- (vii) Paper Chromatography: Unidimensional chromatography, using amino acids from purified samples and biological materials.

  
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(viii) Electrophoresis: Paper/Horizontal/Vertical - Proteins/DNA/RNA.

#### VII. Genetics:

- (i) Culture of Drosophila and study of its life cycle.
- (ii) Identification of male and female Drosophila.
- (iii) Identification of wild and mutant forms of Drosophila.
- (iv) Monohybrid and dihybrid inheritance in Drosophila.
- (v) Simple problems based on Mendelism.
- (vi) Identifications of blood groups in humans.
- (vii) Demonstration of sex chromatin (Barr bodies).

#### VIII. Statistical Methods in Biology:

- (i) Preparation of frequency tables and graphs/line diagrams/bar diagrams/histogram/Pie charts.
- (ii) Calculation of standard deviation, variance and standard error of mean.
- (iii) Calculation of probability and significance between means using t-test and Chi-square test.
- (iv) Plotting the slope of a line on a graph; calculations of the slope of a line, coefficient correlation and regression.
- (v) Exercise based on population genetics.

#### IX. Biodiversity Study:

- (i) Species richness, evenness, Simpson Index.
- (ii) Preparation of fact sheet of common wildlife of your area.



(The candidate are required to go out door for data collection with in campus or outside)

### OBSERVATIONAL AND FIELD STUDIES

There are unlimited amounts of alterntive practicals that can be carried out using observational and other works in the field. Field work also may be encouraged for the students to recognize their social and environmental responsibility. Non-invasive and non-harmful practical exercises, for the study of Anatomy. Physiology, Ethology, Epidemiology and Ecology may be designed.

  
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**M.S. BRIJ UNIVERSITY, BHARATPUR**

**M.Sc. (Previous) Zoology**

**PRACTICAL'S**

**Scheme of practical Examination**

Total Marks- 300

Total Duration: 2 days  
(5 hrs. per day)

I Day (I, II & III Papers)

Time: 5 hrs.

Max Marks: 150

Marks

1. Anatomy	
a. Major	8
b. Minor	5
2. Biodiversity Study	15
3. Spotting No. 1 - 8 (8× 4)	32
4. Cell & Molecular Biology & Biotechnology	15+15
5. Practical Record	20
6. Viva-Voce	20
7. Seminar	20
	Total = 150

II Day (IV, V & VI Papers)

Time- 5 hrs.

Max Marks: 150

Marks

1. Gen. Physiology } Major & Minor	20+5
2. Biochemistry } Major & Minor	20+5
3. Population Genetics & Statistical methods	20
4. Spotting (1 to 5 ) (5× 4)	20
5. Practical Record	20
6. Viva-voce	20
7. Seminar	20
	Total = 150


  
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भरतपुर (राज.)

    
Dr. Anil Kumar  
Dr. Anil Kumar  
Dr. Anil Kumar

**Notes:**

1. With reference to study of anatomy and museum specimens, candidates must be well versed in the study of various systems with the help of charts/models/CD-ROMs, multimedia computer based simulations including computer assisted learning (CAL) and other softwares.
2. With reference to permanent preparations and microscopic slides, the exercise may be substituted with diagrams/photographs/models/charts etc.
3. Candidates must keep a record of all work done in the practical class and submit the same for inspection at the time of the practical examination.
4. The candidates may be asked to write detailed methodology wherever necessary and separate marks may be allocated for the same.
5. Mounting material for permanent preparations would be as per the syllabus or as available through collection and culture methods.
6. **It should be ensured that animals used in the practical exercise are not covered under the wildlife Protection Act 1972 and amendments made subsequently.**

  
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**M.Sc. Final**  
**Zoology**

**3 Hours Duration**

**100 Marks**

- Paper I Biology of Chordates (each Paper)  
Paper II Environmental Biology and Ethology  
Paper III Genes and Differentiations  
Paper IV Tools and techniques in Biology  
Paper V Special Paper  
Paper VI Special Paper  
Laboratory Exercises  
Demonstration and tutorials  
**SEMINAR**

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**PAPER I : BIOLOGY OF CHORDATES**

**Duration : 3 Hours**

**Max. Marks – 100**

**Periods : 70**

**Note :-** The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- i. Question number 1 will be compulsory and will have 20 very short answer question of 1 marks each.
- ii. Question numbers 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these question.
- iii. Question numbers 4 and 5 will be long answer type questions with internal choice.

1. Origin and outline classification of the chordates. 3
2. Interrelationships of Hemichordata, Urochordate and Cephalchordata and their relations with other deuterostomes. 5
3. Life histories of sessile and pelagic tunicates, Ascidia, Pyrosoma, Salpa, Doliolum and Oikopleuro. 8
4. Netoteny 4
5. Origin, evolution and adaptive radiation of Chordates. 20
  - 5.1 Geological time-scale and fossils.
  - 5.2 Origin, evolution and general characters of Agnatha (Ostracoderm and Cyclostomes).
  - 5.3 The early Gnathostomes (Placoderms).
  - 5.4 A general account the Elasmobranchii, Holocephali, Dipnoi and Crossopterygii.
  - 5.5 Adaptive radiation in bony fishes.
  - 5.6 Origin evolution and adaptive radiation of Amphibia.
  - 5.7 Origin and evolution of Reptiles. The conquest of land; Seymouria and related forms cotylosauria, basic type and related forms, Cotylosauria, basic types and outline classification of reptiles.
  - 5.8 Dinosaurs.
  - 5.9 Living Reptiles: a brief account of Rhynchocephalia, Chelonia, Crocodilia and Squamata.
  - 5.10 Origin and evolution of Birds
  - 5.11 Origin of flight: Flight/adaptation.
  - 5.12 Origin of Mammals.
  - 5.13 Primitive Mammals (Prototheria and Metatheria)

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- 5.14 A general survey of the main radiations in eutheria, excluding detailed reference to individual orders.
- 5.15 Evolution of man: Relationship of man with other primates. Fossil record of man's ancestry.
6. Organogenesis 10
- 6.1 Morphogenetic processes in epithelia and mesenchyme, organ formation.
- 6.2 Morphogenesis of the brain; neural crest cells and their accessory organs.
- 6.3 Development of the eye, heart and alimentary canal with accessory organs.
7. Embryonic adaptations 10
- 7.1 Evolution of the cleidoic egg, its structural and physiological adaptations.
- 7.2 Development and physiology of extra-embryonic membranes in amniotes.
- 7.3 Evolution of viviparity.
- 7.4 Development, types and physiology of the mammalian placenta.
8. Metamorphosis in Amphibia
- 8.1 Structural and physiological changes during metamorphosis.
- 8.2 Endocrine control of metamorphosis.
9. Regeneration 5
- 9.1 Type of regeneration (physiological, reparative and compensatory hypertrophy) regenerative ability in chordates.
- 9.2 Morphological and histological process in amphibian limb regeneration.
- 9.3 Origin of cell for regenerations and differentiation.

**Suggested Reading Material :**

- Alexander, R.M. : The Chordata, Cambridge University Press, London.
- Barrington, E.J.W. : The Biology of Hemichordata and Protochordata, Oltter and Boyed, Edinbourgh.
- Bourne, G.H. : The Structure functions of nervous tissues academic press, New York.
- Carter, G.S. : Structure and Habit in Verterate Evolution sedwick and Jackron, London.
- Eccles, J.C. : The understanding of the Brain, McGraw Hill Company new York.
- Kingsley, J.S. : Outlines of Comparative Anatomy of Vertebrates Central Book Depot, Allahabad.
- Kent, C.G. : Comparative Anatomy of Vertebrates.
- Malcom Jollie : Chordata Morphology, East- West press Pvt. Ltd. New Delhi.
- Milton H : Analysis of Vertebrate Structure, John wiley and Sons Ltd. New York.
- Montelli, A.R. : The Chordates, Cambridge University Press, London.
- Smith, H.S. : Evolution of Chordata Structure, Hold Rinehart and Winstoin, Inc, New York.
- Sedgwick, A.A. : Text Book of Zoology. Vol-II
- Tansley, K. : Vision in Vertebrate, Chapman and Hall Ltd., London.
- Torrey, T.W. : Morphogenesis of Vertebrates, Hohn Wiley & Sons, New York.
- Walters, H.E. and Sayles, L.D. : Biology of Vertebrates, Macmillan and Co., New York.
- Romer, A.S. : Vertebrate Body, W.B. Saunders Company, Philadelphia.
- Young J.Z. : Life of Vertebrates, The Oxford University Press, London.
- Colbert, E.H. : Evolution of the Vertebrates, John Wiley & Sons, Inc., New York.
- Romer, A.S. : Vertebrate Palentology, University of Chicago Press, Chicago.
- Clark, W.K., : History of Primates, University of Chocago Press, Chicago.
- Weichert, C.K. and Presch, W. : Elements of Chordate Anatomy, MacGraw Hill Bock Cimpany, New York.
- Messers, H.M. : An Introduction of Vertebrate Anatomy.
- Montagna, W. : Comparative Anatomy, John Wiley & Sons, Inc., New York.
- DeVeer, S.G.: Embryos and Ancestors, Claredon Press, Oxford.
- Andrew, S.M.: Problems in Vertebrate Evolution, Academic Press, New York.

26. Waterman, A.J.: Chordata Structure and Function, MacMillan Co., New York.
27. Joysay, K.A. and Kemp, T.S.: Vertebrate, Evolution, Oliver and Boyd, Edinburgh.
28. Lovtrup, S.: The Phylogeny of Vertebrate, John Wiley & Sons, London.
29. Barbiur T. Hongton : Reptiles and Amchibians : Their Habitats and Adaptations, Miffin Co, New York.
30. Andrevos, S.M., Miles, R.S., Walker, A.D.: Problems in Vertebrate Evolution, Academic Press, New York.

### Paper-II : Environmental Biology and Ethology

**Duration : 3 Hours**

**Max. Marks – 100**

**Periods : 70**

**Note :-** The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- i. Question number 1 will be compulsory and will have 20 very short answer question of 1 marks each.
- ii. Question numbers 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these question.
- iii. Question numbers 4 and 5 will be long answer type questions with internal choice.

#### Unit- I : Environmental Biology

1. Interactions between environment and biota
  - a) Concept of habitat and ecological niches.
  - b) Limiting factors.
  - c) Energy flow, food chain, food web and trophic levels, ecological pyramids.
  - d) Biotic community: Concept, Structure, dominance, fluctuation and succession.
  - e) Various nutrient cycles in nature.
2. Ecosystem dynamics and management
  - a) Self sustaining mechanisms
  - b) Functional aspects and productivity concept.
  - c) Niche, ecotone, and overlapping of niches.
  - d) Character displacement, speciation and extinction.
3. Environmental impact assessment
  - a) Environmental pollution.
  - b) Population and impact of urbanization.
4. Principles of conservation: Conservations strategies
  - a) Various natural resources.
  - b) Present status and future needs.
  - c) Management
  - d) Preserving biological diversity with reference to India and Rajasthan and their sustainable management strategies.
5. Prospects and strategies for sustainable communities.
6. Organization and dynamics of ecological communities.
  - a) The habitat approach.
  - b) A detailed knowledge of communities of fresh water, marine, terrestrial and esturine area with respect to
    - i. Extent,

- ii. Zonation,
  - iii. Environment,
  - iv. Biota,
  - v. Adaptations
7. The ecological outlook
- a) Environmental ethics
  - b) Applied human ecology
  - c) Radiation (electromagnetic and ionizing ) and environment
  - d) Global climatic changes (El Nino and La Nina)
  - e) Space ecology
  - f) Human future

## Unit- II: Ethology

1. Introduction to the study of animal behavior
  - a) Aims of behavioural research
  - b) Diversity of animal behavior
  - c) Ethology : Historical perspective
  - d) Milestones in the study of animal behavior
2. Concepts of ethology
  - a) Fixed action patterns
  - b) Action specific energy
  - c) Sign stimulus
  - d) Innate releasing mechanism.
  - e) Learning and imprinting.
3. Proximate mechanisms in behavior / neuroethology
  - a) Introduction to neuroethology : Cellular mechanisms in behavior
  - b) Neural basis of sensory perception
  - c) Central neural processing
  - d) Neural basis of motor responses
  - e) Brain and behavior
  - f) Behavioural endocrinology
4. Ultimate mechanisms in behavior and behavioural ecology
  - a) Example of agonistic interactions among conspecifics.
  - b) Hardy-Weinberg equilibrium and dispersal and inbreeding.
  - c) Gametes and the evolution of mating and evolution of mating systems.
  - d) Evolution of altruism and eusociality.
  - e) Human socio-biology, human ethology.
  - f) Mating and courtship behavior.
5. Spatial patterns, navigation and communication
  - a) Orientation, navigation, migration and channels of communication.
  - b) Physical properties of signals.
  - c) Field studies on primates: A preliminary knowledge.

- d) Animal communication.
  - e) Biological rhythm and its hormonal control.
  - f) Pheromones; primer and releaser effects.
6. Social organizational orientation
- a) Social organizations and its advantages.
  - b) Evolution of social systems.
  - c) Social groups of bees and monkeys
  - d) Learning:
    - (i) Introduction, definition and types
    - (ii) Habituation, trial and error and conditioning
  - e) Bird song learning behavior in the context of Tinbergens 4 aims
  - f) Parental Care
  - g) Aggression

**Suggested Reading Material (Environmental Biology) :**

1. Begon, M. Harper, J.I. and Townsend, C.R. : Ecology, Individuals, Populations and Communities. Blackwell Science, Oxford University Press, Oxford.
2. Cherrett, J.M. : Ecological Concepts, Blackwell Scientific Publication, Oxford, U.K.
3. Elseth, B.D. and Baumgartner, K.M. : Population Biology, Van Nostrand Co., New York.
4. Orgenson, S.E. : Fundamentals of Ecological Modeling, Elsevier.
5. Krebs, C.J. : Ecology, Harper and Row, New York.
6. Krebs, C.J. Ecological Methodology. Harper and Row, New York.
7. Ludwig, J.A. and Reynolds, J.F. : Statistical Ecology, John Wiley & Sons, New York.
8. Pianka, E.R. : Evolutionary Ecology, Harper and Row, New York.
9. Recklefs, R.E. and Miller, G Ecology, W.H Freeman and company, New York
10. Swartzmen, G.L. and Kaluzny, S.P. Ecological Stimulation Primer, Macmillan, New York.
11. Danial. D. Chiras, Environmental Science (IX edition). Jones and Barlett (Student edition) Burlington
12. Mishra, R, Ecology Workbook. Scientific Publishers, Jodhpur (Raj.)

**Ethology:**

1. Rof, D.A.: The Evolution of Life Histories, Chapman and Hall, London, U.K.
2. Alcock, J. : Animal Behaviour: An Evolutionary Approach, Sinauer Assoc. Sunderland, Mass, USA.
3. Bradbury, J.W. and Vehren Camp. S.L. Principles of Animal Communications, Sinauer Assoc Sunderland Mass, USA.
4. Clutton- Brock, T.H. : The Evolution of Parental Care Princeton Univ. Press, Princeton, USA.
5. Eobi-Eibesfeldt, Holt, I : Ethology, The Biology of Behaviour, Rinehart and Winston, New York.
6. Gould, J.L. : Mechanism of Evolution of Behaviour,.
7. Hauser, M. : The Evolution of Communication, MIT Press, Cambridge, Mass. USA.
8. Hinde, R.A. : Animal Behaviour : A Synthesis of Ethology and Comparative psychology, McGraw Hill Company, New York.
9. Krebs, J.R. and Davis, N.V.: Behavioural Ecology, Blackwell Oxford, U.K.
10. Wilson, E.O.: Sociobiology: The New Synthesis, Harvard University Press, Cambridge, Mass, USA

**Paper – III : Genes And Differentiation**

**Duration : 3 Hours**

**Max. Marks – 100**

**Periods : 70**

Note:- The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- i. Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
  - ii. Question number 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
  - iii. Question numbers 4 and 5 will be long answer type questions with internal choice.
1. Introduction to animal development.
    - a) Problems of developmental biology.
    - b) Developmental patterns in metazoans.
    - c) Development in unicellular eukaryotes.
  2. Creating multicellularity
    - a) Cleavage types.
    - b) Mesoderm and endoderm.
  3. Early vertebrate development
    - a) Neurulation and ectoderm.
    - b) Mesoderm and endoderm.
  4. Cytoplasmic determinants and autonomous cell specification
    - a) Cell commitment and differentiation
    - b) Cell specifications in nematodes
    - c) Germ cell determinants
    - d) Germ cell migration.
    - e) Progressive cell-cell interaction and cell specification fate
  5. Body Axes
    - a) Establishment of body axes in mammals and birds
    - b) Proximate tissue interactions
    - c) Genetics of axis specifications in drosophila.
  6. Homeobox concept in different Phylogenetic groups.
  7. Tetrapod limb development.
  8. Hormones as mediators of development
    - a) Amphibian metamorphosis
    - b) Insect metamorphosis.

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- c) Ovarial luteinization and mammary gland differentiation
9. Environmental evolution and animal development modularity
- Environmental cues and effects.
  - Malformations and disruptions.
  - Changing evolution through development modularity.
  - Developmental constraints.
10. Biology of sex determination
- Chromosomal sex determination – Mammals and Drosophila
  - Testis determination genes.
  - Ovarin development.
  - Secondary sex determination in mammals.
  - Environmental sex determination.
11. Cell diversification in early embryo
- Xenopus Blastomeres.
  - Morphogen gradients.
  - Totipotency & Pluripotency.
  - Embryonic stem cells.
  - Renewal by stem cells-epiderms
  - Skeletal muscle regeneration
  - Connective tissue cell family.
12. Hemopoietic stem cells
- Stem cell disorders.
  - Blood cell formation
  - Bone marrow transplants.
  - Gene therapy.

#### Suggested Reading Material

- Development Biology S.F. Gilbert, Sinauer Associates Inc., Massachusetts.
- Ethyan Bier, the Cold Spring : Cold Spring Harbour Laboratory Press, New York.

#### Paper-IV : Tools And Techniques In Biology

Duration : 3 Hours

Max. Marks – 100

Periods : 70

Question paper will have 5 (five) questions in all having equal marks.

- Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
- Question number 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.

iii. Question numbers 4 and 5 will be long answer type questions with internal choice.

### Section A : Tools

1. Principles and application of
  - a) Light Microscopy and micrometry.
  - b) Phase contrast microscopy
  - c) Interference microscopy
  - d) Polarized microscopy.
  - e) Fluorescence & epifluorescence microscopy.
  - f) Transmission electron microscopy.
  - g) Scanning electron microscopy.
  - h) Co focal scanning and deconvolution microscopy.
2. Principle and Application of
  - a) Ultracentrifugation. Differential and density gradient.
  - b) Electrophoresis: Various media for electrophoresis and various types such as paper, agrose, PAGE, submerged DNA electrophoresis, pulse chase electrophoresis, isoelectrofocussing points and capillary electrophoresis.
  - c) Chromatography: various types such as paper, TLC, GLC, HPLC, ion-exchange and affinity chromatography.
  - d) Freeze techniques; freeze-drying, freeze substitution, freeze fracture and freeze itch.
  - e) X-Diffraction.
  - f) Lambert-Beers Law and colorimetry & spectrophotometry fluorescence, U.V., N.M.R., O.R.D./CD, ESR, IR, Atomic absorption, plasma emission spectrophotometry.
  - g) Flow cytometry/Flourescence activated cell sorter.
3. Principles and application of radiation techniques in Biology
  - a) Radiation dosimetry.
  - b) Radioisotopes and half life of isotypes.
  - c) Tracer techniques in biology.
  - d) Cerendov radiation
  - e) Liquid scintillation.
  - f) Autoradiography.

### Section B : Techniques

1. Assay 2
  - a) Definition and criteria of reliability.
  - b) Chemical Assays.
  - c) Biological Assays-in vivo and in vitro assays.
2. Principles of cytological and cytochemical techniques
  - a) Fixation, chemical basis of fixation by formal dehyde, gluteraldehyde, chromium salts, mercury salts, osmium salts, alchol and acetone.
  - b) Chemical basis of staining of carbobydrates, proteins, liptds and nucleic acids.

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3. Principles and techniques of

M.Sc. (Final) Zoology 2018

PRACTICALS

General Papers:

I. Anatomy\*

(a) Major

- 1) Cranial nerves of *wallago attu*
- 2) Cervical nerves of Rat
- 3) Reproductive organs of Rat.

(b) Minor

- 1) Accessory respiratory organs of *Heteropneustes fossilis*.
  - 2) Labrinth organs of *Anabas testudens*.
- Softwares viz. Digi frog can be purchased, virtual dissections can be substituted

II. Study of Museum Specimens/Models/Charts/Digital media

Lower Chordates	:	Salpa: asexual and sexual stages, Doliolum- oozoid, Botrylus, Herdmania, Amphioxus.
Pisces	:	Petromyzon, Myxine, Rhinobatus, Pristis, Trygon, Chimaera, Polydon, Acipenser, Amia, Lepidosteus, Protopterus, Lepidosiren, Neoceratodus, Notopterus, Exocoetus, Echeuis, Pleuronectes, Mestacembelus, Diodon, Tetradon. Ostracio, Lophis, Syngnathus, Hippocampus, Anguilla, Labeo, Ophiocephalus.
Amphibia	:	Ichthyophis, Necturus, Proteus, Ambystoma, Axolotal, Salamender, Siren, Alytes, Pipa Bufo, Hyla, Rhacophorus, Rana.
Reptilia	:	Testudo, Chelone, Sphenodon, Calotes, Hemidactylus, Phrynosoma, Draco, Varanus, Chameleon, Cobra, Hydrophis, Rattle snake, Viper, Pit, Viper, Krait, Eryx, Gavialis.
Aves	:	Archaeopteryx, Tailor Bird, Indian Koel, Jungle fowl, Peacocok, Columba, Parrot, Wood Pecker, Owl, Flamingo, Great Indian Bustard (models/photographs).
Mammals	:	Ornithorhynchus, Echidna, Macropus, Hedgehog, Manis, Loris, Bat, Mongoose, Hystrix, Otter. Models/photographs/clay models.

III Study of Microscopic slides:

Lower Chordates	:	Herdmania, spicules, herdmania tadpole larva, Amphioxus, T.S. passing through oral hood, pharynx, testes and ovary, intestine and caudal regions. Ammocoele larva (whole mount).
Pisces	:	Placoid scale, cycloid scale, ctenoid scale.

  
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Amphibia	:	V.S. skin of frog, T. S. passing through stomach duodenum, intestine, liver, pancreas, lung, kidney, testis, ovary, spinal cord, bone.
Reptilia	:	V.S. skin of lizard.
Aves	:	V.S. skin of bird, contour feather, down feather.
Mammals	:	V.S. skin of mammal, T.S. passing through stomach, intestine, liver, pancreas, kidney, testes, ovary, thyroid, gland, adrenal gland, lung, bone and spinal cord, L.S./T.S. of pituitary gland; T.S. of simple cuboidal epithelium, simple columnar, simple squamous epithelium, adipose tissue and reticular tissues; Blood smear.

#### IV Comparative Osteology (Models/Charts/Diagrams):

Comparative account of axial and appendicular skeletons of lizard Fowl and Rabbit (both articulated and disarticulated with the help of models, artificial skeleton and bones).

#### V Tools and Techniques

- Operations of various types of microscopes.
- Use of Phase-contrast microscope.
- Use of Fluorescence Microscope and demonstration of nucleic acid by acridine orange or ethidium bromide.
- Preparation of tissue for TEM.
- Tissue homogenization and fractionation by differential centrifugation for isolation of mitochondria, nucleic acids and cytosol and use of marker enzymes for assessment of the purity of the components.
- Demonstration of GLC. Atomic absorption spectrophotometer, CASA etc.
- Standardisation of oculometer and measurements of tubular diameter, cell heights, nuclear diameters, etc.

#### VI Exercises on Environmental Biology, Ethology and Developmental Biology can be framed as per the syllabus of the theory paper and infrastructure of the Department.

- Light – penetration, quantitative study of planktons, Light intensity, organic matter residual chlorine, study of local habitats (Terrestrial/aquatic) preparation of fact sheets of Endangered species (other exercises on acidity, alkalinity, hardness, dissolved  $\text{CO}_2$ ,  $\text{O}_2$ , can also be included).
- Role of hormones is metamorphosis.
- Maze learning and habituation.

#### Practically (M.Sc. Final, General Paper)

##### Scheme of Practical Examination

Exercise

Marks

1. Anatomy	
a. Major	5
b. Minor	3
2. Ethology	15
3. Environmental Biology	20
4. Tools and techniques	15
5. Embryology	15
6. Spotting (No 1-8)	32
7. Practical record	15
8. Viva- voce	15
9. Seminar	15
	<b>Total = 150</b>

**Notes:**

1. With reference to anatomy and study of museum specimens, candidates must be well versed in the study of various systems with the help of charts/models/CD-ROMs, multimedia computer based simulations including computer assisted learning (CAL) and other softwares.viz. Dig frog
2. With reference to permanent preparations and microscopic slides, in case of non- availability, the time of the practical examination the exercise should be substituted with diagrams/ Photographs models/charts.
3. Candidates must keep a record of all work done in the practical class and submit the same for inspection at the time of the practical examination.
4. The Candidates may be asked to write detailed methodology wherever necessary and separate marks may be allocated for the same.
5. Mounting material for permanent preparations would be as per the syllabus or as available through collection and culture methods.
6. It should be ensured that animals used in the practical exercise are not covered under the wildlife protection act 1972 and amendments made subsequently.

**Special Paper for M.Sc. Zoology (Final)**

Candidate can opt any one special paper out of the following:

- 1. Entomology**
- 2. Fish Biology**

Note:- The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- i. Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
- ii. Question number 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
- iii. Question numbers 4 and 5 will be long answer type questions with internal choice.

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## 1. ENTOMOLOGY

### Paper – V : Morphology and Physiology

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Integument: Structure, composition and functions, biochemistry of sclerotization.
2. Functional Morphology of head, thorax and abdomen including head segmentation and appendages.
3. Muscular system.
4. Digestive system: Alimentary canal and physiology of digestion.
5. Circulatory system: Morphology and Physiology including composition of haemolymph.
6. Respiratory system: Structure of respiratory organs and physiology. Adaptations for aquatic respiration.
7. Excretory system: Structure of excretory organs and physiology of excretion.
8. Nervous system: Morphology and physiology.
9. Neuroendocrine system: Morphology and physiology.
10. Sense organs: Mechanoreceptors, Chemoreceptors auditory organs, sound and light producing organs, visual organs and physiology of vision.
11. Reproductive systems: Structure and physiology.
12. Embryology: Structure of egg, embryonic and postembryonic development, types of larvae, pupae and metamorphosis, role of endocrine in growth and development, diapause, viviparity and parthenogenesis.

## 1. ENTOMOLOGY

### Paper – VI : Systematics, Ecology And Applied Entomology

Duration : 3 Hours

Max. Marks – 100

Periods : 90

Note:- The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- iv. Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
- v. Question number 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
- vi. Question numbers 4 and 5 will be long answer type questions with internal choice.
  1. Classification of insects up to orders and suborders, basis and short history of classification. Introduction to primitive insects.
  2. Detailed classification of important and selected super families and families of the following orders. Orthoptera, Isoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera.
  3. Social life in Isoptera and Hymenoptera.
  4. Life cycle of Locusts and Aphids.

5. Origin and Evolution of insects with special reference to fossil - insects; causes of success of insects.
6. Ecology of Insects
  - 6.1 Effect of Physical factors.
  - 6.2 Intra –Interspecific relations.
  - 6.3 Population dynamics
  - 6.4 Host-Plant interactions
7. Biochemical adaptations to environmental stress (Metamorphosis, Diapause, Polymorphism etc.)
8. Concept of pest – How and Why an insect become pest?
9. History, damage caused and control of major pests of-
  - 9.1 Cash crops: Sugarcane, Tobacco, mustard
  - 9.2 Cereal Crops : Wheat ,Paddy, Maize millet, sorghum, and Lentils.
  - 9.3 Pest of vegetable crops : Fruits and oil seed crops
  - 9.4 Cash fibre crops: cotton and sun hemp etc.
  - 9.5 Pests of Medical and veterinary importance with reference to role of WHO and UNICEF. Insect borne disease (A preliminary idea)
  - 9.6 Storage pest –(stored grain and milled products with an elementary idea of different storage).
10. Pest control: Basic idea, EIL, and ETL.
  - 10.1 Various methods of pest control  
Prophylactic and cultural methods, quarantine regulations
  - 10.2 Physical control
  - 10.3 chemical control
  - 10.4 Biological control
  - 10.5 Chemistry and mode of action of insecticides –  
Inorganic insecticides, Organochlorine insecticides, organophosphorus compounds and carbamates.
  - 10.6 Insecticides of plant origin
  - 10.7 Synthetic pyrethroids
  - 10.8 Insect growth regulators.
  - 10.9 Microbial insecticide
  - 10.10 Chemosterilant, repellent and antifeedants
  - 10.11 Fumigants and fumigation

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11. First, second and third generation Pesticides
  - 11.1 Role of nanotechnology in Pest management .
12. A brief idea of appliances used for application of insecticides, hazards involved and safe handling of insecticides.
  - 12.1 Development of resistance in insects to insecticides.
  - 12.2 Insecticide synergists and antagonists.
  - 12.3 Insecticide formulations and application technology.
  - 12.4 Dynamics of environmental pollution
  - 12.5 Pesticides: their impact on wildlife and human health (bioaccumulation, biomagnification, biodegradation).
  - 12.6 Microbial and environmental degradation of pesticides.
13. Forensic entomology with special reference to man and wild life.
14. Beneficial insects : Silk worm, honey bee, and lac insect and industries related to them.
15. Role of genetics and Biotechnology in vector control.
16. Social insects : Social organization, Caste Differentiation.

**Scheme of Entomology Practical Examination**

Duration 5 hrs.	MM. 150.
1. Study of Anatomy of insect-	
a) Major	10
b) Minor	5
2. Permanent Slide Preparations	09(7+2)
3. Identification of Four insects (A to D)	24
Using Taxonomic Keys	
4. Exercise based on Physiology/Ecology/Behavior/Bioassay	15
5. Microtomy procedures & slide Preparations	05
6. Identification & spot (1to 8)	32
7. Field work /report-	10
8. Practical Record	20
9. Viva Vose	20
<b>Total</b>	<b>150</b>

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### List of Practical's :

1. Field trips for collection and preservation of insects of various orders.
2. Museum study for identification of insects of different orders.
3. Dissection-
  - (a) Cockroach: Digestive, nervous, circulatory, reproductive systems and neuroendocrine complex
  - (b) Grass Hopper: Digestive, nervous, circulatory, reproductive system
  - (c) Honeybee: Digestive and nervous system.
  - (d) White grub: Nervous system.
  - (e) Housefly: Nervous system, Digestive system
4. Permanent preparations-
  - (a) Different types of mouthparts, antennae, legs and wings.
  - (b) Sting apparatus of honeybee.
  - (c) Pollen basket of honeybee.
  - (d) Tympanum and spiracle of grasshopper.
  - (e) Whole mounts (W.M.) of various small insects.
5. Familiarity with techniques of appliances used for the application of insecticides-
  - (a) Sprayers including hand sprayers.
  - (b) Dusters.
6. Knowledge of rearing insects and maintaining insectary-
  - Tribolium sp.
  - Rhizopertha dominica.
  - Helicoverpa sp.
  - Corcyra cephalonica.
  - Callosobruchus sp.
  - Lasioderma serricorne.
  - Oryzaephilus surinamensis.
  - Mosquito sp.
7. Testing of insecticides: Bioassay method.
8. Study of Permanent prepared slides
  - Whole mounts of insects
  - Histology
  - Different types of legs, mouthparts, antennae and wings
9. Microtomy of internal organs of insects.
10. Study of seasonal abundance of crop pest in nearby area Demonstration of biological control using coccinella or chrysopa
11. Role of hormones in metamorphosis (ligature experiment with housefly larva )
12. Antennal grooming in cockroach
13. Study of blood cell types in insects

14. Study of meiosis and Polytene chromosome in insects
15. Study of insect infestations in grains
16. Study of food and light preference in Tribolium or any other insects.

**Recommended Books: Entomology:**

1. Chapman R.F. The Insects: Structure and Functions, Cambridge Low Price, Edition, 1998.
2. Imms. A.D.: A General Text book Entomology, Methuen and Co.: London. 1957 (Low priced reprint; English Language Book, London, 1972.)
3. Imms, A.D.: Recent Advances in entomology. Chrchill. London. 1931.
4. Metcalf. C.L. and Flint. W.P.: Destructive and useful Insects. Mcgraw Hill Book Co.: New York. 1962 (Indian reprint: Tata Mcgraw-Hill Publ. Co.: New Delhi.
5. Pruthi, H.S.: Text book of Agricultural entomology Indian council of Agricultural Research, New Delhi. 1969.
6. Wigglesworth. VB.: The principle of insects Physiology. Methuen and Co. London. 1972 (Low Priced text reprint: English Language Book Society London.1972)
7. Roeder, K.D. Insect physiology: John Wiley and Sons Inc. New York, 1953.
8. Snodgrass, R.E.: Principles of Insect Morphology. McGraw-Hill Co. New York. 1953.(Indian Reprint Tata McGraw- Hill Publ.Co. New Delhi, 1971.
9. Mani, M.S.: General Entomology. Oxford and IBH. Publ. Co., New Delhi. 1978.
10. Mani, M.S.: Modern Classification of Insects. Satish Book Enterprise, Agra. 1974.
11. Borror. D.J. and DeLong. D.M. : An Introduction to the study of Insects. Constable and Co. London/Holt. Rinart and Winston. New York. 1954.
12. Essig, F.Q. College Entomology MacMillan Co. New York. 1942.
13. Fox, R.M. and Fox, J.W.: Introduction to comparative Entomology, Rivehold Puse, Corp, New York, 1964 (Indian Reprint Affiliated East West press, Pvt. Ltd., New Delhi.
14. Frost, S.W. Insect Life and Insect Natural History dover puse. Inc. New York, 1969.
15. Lefroy, H.F.: Indian Insect life. Today and tomorrow printers and Publishers, New Delhi, 1971.
16. Lefroy, H.F.: Indian Insect Pest. Today and tomorrow printers and Publishers, New Delhi 1971.
17. Trigunayat, M.M. A Manual of Practical Entomology (Field & Laboratory guide) Scientific Publishers, Jodhpur (Rajasthan).

**2. Fish Biology**

**Paper-V: Morphology and Physiology of Fishes**

**Duration: 3 Hours**

**Max. Marks – 100**

**Periods: 90**

**Total No. of Lectures: 90**

Note:- The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- i. Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
- ii. Question number 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
- iii. Question numbers 4 and 5 will be long answer type questions with internal choice.



1. Classification of fishes with special reference to evolutionary trends and adaptations.
2. Integument and exoskeleton
3. Fins : Types of fins structure, modifications and functions of fins.
4. Locomotion : Locomotor Muscle, the red (slow) and white (fast) muscle fiber types; modes of swimming and hydromechanics of propulsion; role of fins in swimming; significance of swimbladder in swimming; non-swimming locomotion.
5. Food, feeding habits and feeding adaptations/behavior; structure of the alimentary canal and physiology of digestion and absorption.
6. Planktons: Classification, common organisms and their importance; algal bloom, nutrient cycle, trophic levels and energy flow.
7. Blood vascular system : Structure of the heart; principal blood vessels and circulation of blood (elasmobranch, teleost and Dipnoi).
8. Gills and aquatic respiration. Organization of gills in fishes; structure of a typical teleostean gill, physiology of gill respiration: gill ventilation, gill surface area, blood flow through gills, water-blood barrier, gas exchange at the gill surface and gas exchange between blood and tissues.
9. Air breathing fishes; causative factors and structural adaptations.
10. Structure and functions of the swimbladder.
11. Water and electrolyte regulation in marine fresh water and euryhaline fishes.
12. Structure and function of the swimbladder.
13. Study of feeding habits of fish through qualitative and quantitative analysis of gut contents of herbivorous carnivorous and omnivorous species.
14. Nervous system: Structure and functions of the central, peripheral and autonomic nervous systems; anatomy and function of the Mauthner neurons.
15. Structure and functions of the sense organs:
  - i) Eye; visual pigments and vision.
  - ii) Chemoreceptors: Olfactory and gustatory; biological significance of chemoreception.
  - iii) Labyrinth.
  - iv) Mechanoreceptors (lateral line organs.)
16. Structure and physiology of the endocrine organs and tissues:
  - i) Pituitary
  - ii) Thyroid
  - iii) Gonads.
  - iv) Adrenal
  - v) Endocrine pancreas
  - vi) Bronchial
  - vii) Caudal neurosecretory cells and urophysis.
  - viii) Pineal.
17. Reproduction: Organs of reproduction; modes of reproduction; oviparity, viviparity hormonal and environmental regulation of reproduction, Aging and growth of fish.
18. Reproduction behavior: Secondary sexual characters, nest building and parental care.
19. Development: Types of eggs; fertilization; hatching and metamorphosis.
20. Adaptations: Coloration, sound production, electric, organs, luminescent organs (location, structure, physiology and biological significance).
21. Adaptations in deep sea, hill-stream and cave-dwelling fishes; freezing avoidance in arctic and Antarctic fishes.
22. Migration; its types and causes.
23. Fish pathology: Symptoms, etiology, prophylaxis and treatment of common diseases and pathological conditions in cultivable fish.

24. Immune protection in fish systems and stress.
25. Setting-up and maintenance of an aquarium.
26. Fish products and byproducts; Liver oil, body oil, meal, fish manure, guano, glue, isinglass, roe (caviar), fins and leather.

## 2. Fish Biology

### PAPER-VI: AQUACULTURE AND FISHERIES

**Duration : 3 Hours**

**Max. Marks – 100**

**Periods : 90**

Note:- The theory paper of M.Sc. Final (Zoology) will have the following pattern.

Question paper will have 5 (five) questions in all having equal marks.

- i. Question number 1 will be compulsory and will have 20 very short answer question of 1 mark each.
  - ii. Question number 2 and 3 will consist of only short answer type questions with 4 subdivisions of 5 marks each. There will be internal choice in these questions.
  - iii. Question numbers 4 and 5 will be long answer type questions with internal choice.
1. Definitions of (a) inland, (b) marine (c) capture fisheries.
  2. Riverine fisheries: Ecology and fisheries of the major river systems; effects of dams and barrages on riverine fisheries.
  3. Reservoir fisheries: Location, ecology and fisheries of some important reservoirs: development, exploitation and management of reservoir fisheries.
  4. Coldwater fisheries: Ecology of high altitude streams, lakes and reservoirs; present status and scope for development important coldwater fisheries.
  5. Estuarine fisheries: Ecology and fishery resource of major estuaries; potential and management of estuarine fisheries.
  6. Marine fisheries :
    - 6.1 Ecology and general survey of marine capture fishes with special reference to sardine, mackerel, Bombay duck and pomfret.
    - 6.2 Offshore and deep sea fishery potential in EEZ (Exclusive economic Zone)
  7. Estimation of fecundity and population. Population dynamics and fishery catches.
  8. Growth and age; environmental factors and methods.
  9. Crustaceans and Molluscan fisheries (Marinewater, Brackishwater and Freshwater) culture of edible oyster and shrimps.
  10. Methods of Fishing: Crafts (non-mechanised and mechanized) and gears used in India for fishing in inland and marine water; recent advances in fishing method, electrical fishing; light fishing, fish finders (Eco-sounder and sonar) and their use.
  11. Transport and preservation of fish: Methods of transport, post-mortem changes and rigor mortis in fish; spoilage (bacterial and chemical); fish preservation-handling and cleaning of fresh fish, ceiling, freezing, quick freezing, use of chemicals and antibiotics, irradiation, salting, drying, freeze-drying, smoking, canning and pickling.
  12. Fishery management: fish yield, effect of fishing on yield and optimum catch; concept of a rational fishery.

13. Ecology and Productivity of freshwater lake and perennial fishpond indices of productivity, physical and chemical characteristics of water, nature and fertility of the soil.
14. Environment and fish. Environmental factors (abiotic and biotic), interrelation to the life of fishes; pollution of aquatic ecosystems sources of pollution and nature of pollutants, effects of pollution on fisheries, legislative and other remedial measures to contain aquatic pollution.
15. Freshwater fish culture in India; Fish seed resources (riverine, bundh breeding, hypophysation) hatching of eggs, hatchlings, 'hapas' and different types of hatcheries, management of hatcheries; methods of transporting fish seed, fingerlings and breeders; causes of mortality during transportation and measures for reducing it.
16. Planning and management of freshwater ponds for fish culture (freshwater fish-farming); survey of site, layout, soil and water requirements; preparation of nursery, rearing and stocking ponds; control of predators and weed fishes; liming and manuring; control of aquatic insects and weeds; procurement and segregation of fish seed; stocking rates; stocking ratios of different species for composite culture; artificial feed and supplement feeding, harvesting.
17. Culture of Indian major carps (rohu, catla and mrigal) exotic carps Common carp, grass carp, silver carp and tilapia. Composite culture principle, techniques and significance: Wet and dry bundh technique, induced breeding, hypophysation, selective breeding and hybridization.
18. Cold-water culture of trout: mahseer, culture method and management.
19. Larvivorous fishes and their importance.
20. Nutrition and physiological energetic: Nutritional requirement of fish with reference to proteins, lipids, carbohydrates, vitamins and minerals; essential amino acids and essential fatty acids; energy requirements; food conservation, efficient energy budgets.
21. Fish as food: Biochemical composition of raw fish, factors affecting biochemical composition of fish; nutritive value of raw and preserved fish; poisoning, toxicity and allergies from fish as food; quality control of fish as food.
22. Fisheries education, training and extension in India : Brief information about the objectives and functions of central Institute of Fisheries Education (Bombay) Central inland capture Fisheries Research Institute (Barrackpore) Central institute of Freshwater aquaculture (Chennai), National Bureau of Fisheries Genetics Resources (Allahabad), Central Institute of Fisheries Research Institute (Cochin), Central Institute of Fisheries Nautical and Engineering Training (Cochin), Central Institute of Fisheries Technology (Cochin) and National Institute of Oceanography (Done Paula).

#### List of Practicals Exercises:

1. Study of distinguishing features, identification and classification of specimens of important species of fish available in the museum; Collection of local fish fauna and its identification upto the species level using taxonomic keys.
2. Anatomy and Histology:
  - a) Study of anatomy of teleost represented by the catfish wallago attu: External anatomy and gills, uiscera, alimentary canal and urinogivetal organs; musculature of gill ventilation, and feeding; eye muscles and their innervations, endosketion (through dried and alizarin preparation). Branchial blood vellels, brain and cranial nerves, swim bladder, weberian ossicles, membranous labyrinth connections.
  - b) Preparation and study of stained permanent mounts of ampullae of Lorenzini (from Dasyatis), otolith, weberian ossicles, membranous labyrinth connections.
  - c) Dissection of air-breathing organs and their blood supply in Anabas testudineus, Clarias batrachus, He tropneustes fossilis and channa sp.

3. Preparation of microscopic slides of stained sections of following organs/tissues/structures from and adult teleost for their histological study of liver, intestine, kidney, testis, Ovary, gill, pituitary, thyroid tissue, head kidney (for interregal and chromaffin cells).
4. Physiology and biochemistry:
  - a) Study of the effect of epinephrine, NaCl and KCl on fish chromatophores.
  - b) Study of changes in chromatophores of fish kept against white (light) and black (dark) backgrounds for protracted periods.
  - c) Determination of the rate of oxygen consumption (Winkler method) in a water breathing fish at different temperatures.
  - d) Determination of the rate of ammonia and urea excretion in fish.
  - e) Estimation of protein, fat, ash and water contents in fish muscle.
  - f) Study of free amino-acid pool in fish muscle through paper chromatography.

5. Basic Laboratory Techniques:

Maintenance of fish in freshwater: Setting up to an aquarium, quality of water in the aquarium and its aeration: Introduction of fish in the aquarium; feeding of fish and management of aquarium.

Ecology : Physico-chemical analysis of water.

Age and growth.

Identification of maturity stages of fish; determination of gonosomatic index; estimation of fecundity; measurement of ova diameter.

Plankton, Benthos and Primary productivity: Collection of plankton and its qualitative and quantitative analysis; identification of common groups of freshwater plankton; collection and analysis of benthos from a freshwater fish pond, identification of moomor, weeds, predaiory fishes and harmful insects in a fresh water fish pond or lake by dark and light bottle method.

Identification of Important cultivable species of fish, their eggs and principal stages in their life histories.

Induced breeding through hypophysation. Dissection, collection and preservation of pituitary gland; preparation of pituitary gland extract; dosage and technique of injecting pituitary gland extract.

Water Analysis; determination of water temperature light turbidity. Dissolved oxygen, dissolved carbon dioxide, ammonia, salinity, alkalinity, nitrates, phosphates, pH, particle size, available nitrogen and free calcium carbonate.

Fish anesthetics and anesthetization; simple surgical procedure (gonadectomy), fish saline.

Fieldwork and study tour

- a) A visit to a farm/fish seed production centre.
- b) 3 to 4 day tour to study various fisheries activities at selected centres/sites.

### Scheme of Fish Biology Practical Examinations

**Durations 5 hrs.**

**Max. Marks. 150**

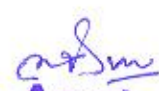
1. Study of Anatomy of suitable fish	
i. Major	10
ii. Minor	05
2. Physiology / Biochemistry exercises	10
3. Microtome procedures and preparation of slides.	08
4. Identification and comment upon the spot (1-8)	(8x4)- 32

5. Plankton identification/primary productivity / water analysis	10
6. Identification of fish using taxonomic keys	10
7. Determination of age/Growth/ maturity stage/ GSI	15
8. Field work / report	10
9. Practical record-	20
10. Viva-Voce	20
<b>Total</b>	<b>150</b>

*Books recommended*

**(FISH BIOLOGY)**

1. Hoar, W.S., Randall, D.I. (eds) : Fish Physiology, Vol. 1 to 11 Academic Press.
2. Norman, I.R. : A History of Fishes.
3. Brown, M.E.: The Physiology of Fishes, Vol I & II.
4. Lagler, K.F.: Ichthyology, Wiley & Sons, New York.
5. Chandy, M. : Fishes, National Book Trust, India.
6. Bond. B.C.: Biology of fishes, Saunders, Philadelphia.
7. Jhingran, V.G.: Fish and Fisheries of India, Hindustan Publication Corp., India.
8. Day, F.: The Fishes of India, William Dawson and Sons, London.
9. Jayram, K.C. The fresh water fishes of India; A Hand book, Zoological Survey of india, Kolkata.

  
**OIC, Academic**  
**M.S. Brij University**  
**Bharatpur**

  
 28.6.18

  
 29/8/18