UNIVERSITY OF RAJASTHAN, JAIPUR

SYLLABUS

SCHEME OF EXAMINATION AND COURSES OF STUDY

FACULTY OF SCIENCE

M.Sc. ZOOLOGY

2013-2015

UNIVERSITY OF RAJASTHAN, JAIPUR

SCHEME OF EXAMINATION
M.Sc. ZOOLOGY
(Annual Scheme)

Each Theory Paper	3 hrs. duration	100 Marks
Dissertation/Thesis Survey Report/Field Work, if any		100 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, wherever prescribed, he shall be deemed to have failed at the examination 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, as noted below.

First Division	60%	of the aggregate marks taken together of the previous and the final examination
Second Division	48%	

3. All the rest will be declared to have passed the examinations.
4. If a candidate clears any Paper(s) Practical(s)/Dissertation prescribed at the previous and/or final examinations after a continuous period of three years, then for the purpose of working out his division the minimum pass marks only viz. 25% (36% in the case of practical) shall be taken into account in respect of such Paper(s)/Practical(s)! Dissertation are cleared after the expiry of the aforesaid period of three years; provided that in

case where a candidate requires more than 25% marks in order to reach the minimum aggregate as many mark out of these actually secured by him to make up the deficiency in the requisite minimum aggregate.

5. The Thesis/Dissertation/Survey/Report/Field Work shall be typewritten and submitted in triplicate so as to reach the office of the registrar at least 3 weeks before the commencement of the theory examinations. Only such candidates shall be permitted to offer Dissertation/Field Work/Survey Report/Thesis (if provided in the scheme of examination) in lieu of a paper as have secured at least 55% marks in the aggregate of all the papers prescribed for the previous examination in case of annual scheme irrespective of the number of papers in which a candidate actually appeared at the examination.

N.B. Non-collegiate candidates are not eligible to offer dissertation as per provisions of 0.170-A

UGC CURRICULUM FOR POSTGRADUATES

M.Sc. PREVIOUS (ANNUAL SCHEME)

Paper - I	Biosystematics and Taxonomy
Paper - II	Structure & Function of Invertebrates
Paper - III	Molecular Biology and Biotechnology
Paper - IV	General Physiology
Paper - V	Biochemistry
Paper - VI	Quantitative Biology and Population Genetics
	Laboratory Exercises
	Demonstration and Tutorials
	SEMINAR

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-I : BIOSYSTEMATICS AND TAXONOMY

3 Hours duration **Max.Marks: 100** **Periods : 80**

Theory paper will have the following pattern.

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

(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.

1. Definition and basic concepts of biosystematics and taxonomy. 10
   1.1 Historical resume of systematics.
   1.2 Importance and applications of biosystematics in biology.

1.3 Manual basis of histo-systematics-different attributes.

2. Trends in biosystematics: Concepts of different conventional and newer aspects 14
   2.1 Chemotaxonomy
   2.2 Cytotaxonomy
   2.3 Molecular taxonomy
3. Molecular perspective on the conservation of diversity 6
   3.1 Diversity and ecosystem process: Theory, achievements and future directions.
4. Dimensions of speciation and taxonomic characters 20
   4.1 Dimensions of speciation - Types of lineage changes: production of additional lineage.
   4.2 Mechanisms of speciation in panmictic and apotmictic species.
   4.3 Species concepts 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.
5. Procedure keys in taxonomy. 20
   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 10
   6.1 Shannon-Weinner index, dominance index.
   6.2 Similarity and dissimilarity index
   6.3 Association index

Suggested Reading Material (All latest editions)

– 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., Principle of Animal Taxonomy. Oxford, IBH Publishing Company.
- Mayer, E., Principles of Systematic Zoology, McGraw Hill Book Company, New York.
- Wilson, E.O., The Diversity of Life. W.W. Northern & Company.
- Tikadar, B.K., Threatened Animals of India, ZSI Publication, Calcutta.

PAPER-II : STRUCTURE & FUNCTION OF INVERTEBRATES

3 Hours duration **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.

1. Organization of Coelom 6
   - 1.1 Acoelomates
   - 1.2 Pseudocoelomates
   - 1.3 Coelomates: Protostomia and Deuterostomia.
2. Locomotion 14
   - 2.1 Flagellar and ciliary movement in Protozoa.
   - 2.2 Hydrostatic movement in Coelenterata, Annelida and Echinodermata.
3. Nutrition and Digestion 10
   - 3.1 Patterns of feeding and digestion in lower Metazoa.
   - 3.2 Filter feeding in Polychaeta. Mollusca and Echinodermata.
4. Respiration 10
   - 4.1 Organs of respiration: Gills, lungs and trachea.

4.2 Respiratory pigments.
4.3 Mechanism of respiration

5. Excretion 8
   5.1 Organs of excretion: Coelom, Coelomoducts, Nephridia and Malpighian tubules.
   5.2 Mechanisms of excretion.
   5.3 Excretion and osmoregulation
6. Nervous System 12
   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 10
   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 10
   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. 2, 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. Branes, 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, C.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

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.

1. DNA replication 18
   - 1.1 Prokaryotic and eurokaryotic DNA replication
   - 1.2 Mechanics of DNA replication
   - 1.3 Enzymes and accessory proteins involved in DNA replication
2. Transcription 10
   - 2.1 Prokaryotic transcription
   - 2.2 Eukaryotic transcription
   - 2.3 RNA polymerases
   - 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 10
   - 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 10

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 10
   5.1 Holliday junction, gene targeting, gene dissruption
   5.2 FLP/FRT and Crelox recombination
   5.3 RecA and other recombinases
   5.4 DNA repair mechanisms
6. Molecular mapping of genome 10
   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 AFLP analysis.
   6.5 Application of RFLP in forensic, disease prognosis, genetic counselling, pedigree, varietal etc. analysis. Animal tracking and poaching; germplasm maintenance and taxonomy
7. Transgenic animals and knock-outs 10
   7.1 Production
   7.2 Applications
   7.3 Embryonic stem cells
   7.4 Care and breeding of experimental animals including bioethics
8. Assisted reproduction technologies 10
   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., Weiner, 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., Fristsch, 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. 1, Bio Scientific Publishers Ltd, Oxford.
9. Karp, G., Cell and Molecular Biology, Concepts and Experiments, John Wiley & Sons, Inc., New York.

PAPER-IV: GENERAL PHYSIOLOGY

Duration: 3 Hours **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.

1. Thermoregulation and Cold Tolerance 8
   1.1 Basic principles of metabolism
   1.2 Heat balance and exchange
   1.3 Endotherms Vs Ectotherms
   1.4 Counter-current heat exchanger
   1.5 Torpor, hibernation and aestivation
   1.6 Adaptations to very cold environments
2. Ionic and Osmotic Balance. 8
   2.1 Osmoregulation vs. osmoconfirming

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 8
3.1 Oxygen and carbon dioxide transport in blood
3.2 The role of hemoglobin
3.3 Responses to attitude 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

4. Muscle Function and Movement 8
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 8
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 10
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 and bats

7. Digestion and Metabolism 5
7.1 Nutritional uptake and distribution
7.2 Effects of starvation

8. Stress Biology 10

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 15
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. Schiemadt 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.
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, Harloss, 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., Clark, H.B., Ralpls, C.L. Comparative Endocrinology, Wiley- Interscience Publication, New York.

PAPER-V: BIOCHEMISTRY

Duration: 3 Hours **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.

1. Covalent properties of Proteins 6
   - 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 6
   2.1 Protein tertiary structure and folding patterns.
   2.2 Common tertiary structural motifs.
   2.3 Role of packing constraints in tertiary structure patterns.
   2.4 Divergent vs. convergent evolution of similar structure.
3. Globular and fibrous proteins. 5
   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 5
   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), Myglobin structure and oxygen binding 3
   5.1 Hemoglobin subunits coopertavity, the Hill coefficient.
   5.2 Quarternary structure changes and Sickle cell and other molecular diseases.
6. Fats 10
   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 10

7.1 Classification, occurrence of fat soluble vitamins.
7.2 Classification, occurrence and biological functions of thiamin, riboflavin, folic acid and B_{12}.
7.3 Phenolics and alkaloids: Structure, biological properties and functions.

8. Covalent properties of nucleic acids. 5
   8.1 Modified nucleosides.
   8.2 Properties of polynucleotides.
   8.3 Secondary and tertiary structure.
9. Nucleic acid structure 5
   9.1 Duplex stability.
   9.2 Hybridization.
   9.3 RNA structure.
   9.4 Hairpin and pseudoknot structures, tRNA.
10. Nucleic acid structure 5
    10.1 DNA and RNA helical geometrics (A-Z). banding, deformation triplexes, quadruplexes.
11. Nucleic acid analysis. DNA and RNA sequencing, determination of modified nucleotides. Analysis of nucleic acid secondary structure. 4
12. RNA catalysis 3
    12.1 Chemistry and structure of ribozymes.
    12.2 Evolutionary implications.
13. Enzyme mechanisms 8
    13.1 Principles of enzyme catalysis.
    13.2 Proteases and polymerases, other examples.
    13.3 Coenzymes and Cofactors.
14. Inborn errors of metabolism. 5

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. VoetJ.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., Rodwell V.W., McGraw Hill Publication, 2000.
9. Mathews, C.K., Van Holde, K.E., Ahern, K.G., Biochemistry, Pearson Education Pvt. Ltd., Delhi, India, 2003.
10. Horton, H.R., Morsan, L.A., Scrimgeour, K.G., Perry, M.D., Rawn, J.D., Principles of Biochemistry, Pearson Educations, 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: QUANTATIVE BIOLOGY AND POPULATION GENETICS

Duration: 3 Hours **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 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.

Unit I : Quantitative Biology

1. Basic Mathematics for Biologists 8
   1.1 Matrices and vectors.
   1.2 Exponential functions.
   1.3 Periodic functions.
   1.4 Different equations, integration.
2. Principles and practice of statistical methods in biological research, samples and populations 10

2.1 Basic statistics-average.
2.2 Statistics of dispersion, coefficient of variation.
2.3 Standard errors; Confidence limits.
2.4 Probability distributions (binomial, Poisson and normal).
2.5 Tests of statistical significance.
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 an emphasis on Drawinism. 5
2. Neo-Darwinism 10
   2.1 Hardy-Weinberg's law of genetic equilibrium.
   2.2 detailed account of distabilizing 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 5
   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. 10
   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 10
   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 10
   - 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 12
   - 7.1 Construction of phylogenetic trees.
   - 7.2 Phylogenetic inference-distance methods, parismony 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 (Quantative Biology).

1. Batschelet, E: Introduction to Mathematics for Life Scientists Springer, Verlag, Berlin.
2. Jorgenson, S.E.: Fundamentals of Ecological Modeling, Elseiver Press, New York.
3. Swartzman, G.L. and Kaluzny S.P.O. : Ecological Stimulation Primer. MacMillan, New York.
4. Lendern, D., Modelling in Behavioural Ecology, Chapman and Hall, London, U.K.
5. Sokal, R.R. and Rolf, F.J.: Biometry; Freeman, San Francisco.
6. Snedecor, H.W. and Cochran, W.G., Statistical Methods. Affiliated East-West Press, New Delhi.
7. Green, R.H.; Sampling Design and Statistical Methods for Environmental Biologists, John Wiley & Sons, New York.
8. Murray, J.D., Mathematical Biology, Springer-Verlag, Berlin,

Suggested Reading Material (Population Genetics)

1 Dobhzhamsky, T., Alaya, F.J., Stebbins, G.L., Valentine, J.M, Genetics and Origin of Species, Surjeet Publication, Delhi.
2 Futuyamma, D.J., Evolutionary Biology, Suinuauer Associates, Inc., Massachusetts, U.S.A.
3 Hart, D.L., A Primer of Population Genetics, 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 Charrge Cambridge University Press, Cambridge.
6 Merral, D.J., Holt, R. Evolution and Genetics, Rinchart and Winston, Inc.
7 Smith, J.M., Evolutionary Genetics, Oxford University Press, New York.
8 Strikberger, M.W., Evolution, Jones & Barlett Publishers, Boston, London.

PRACTICALS

Scheme of Practical Examination

Total Marks–200 **Total Duration–2 days (8 hrs. perday)**

I Day (I, II & III paper)

Max Marks–100	**Time–8 hrs. Marks**
1. Major Dissection	18
2. Mounting/Minor dissection	10
3. Biodiversity Study	8
4. Spotting (Invertebrates) No. 1-8	24
5. Cell mol. Biol. & Biotechnology	10
6. Practical Record	10
7. Viva-Voce	10
8. Seminar	10
	Total = 100

II Day (IV, V & VI paper)

Max Marks–100	**Time–8 hrs.**
1. Gen. Physiology exercise	20
2. Biochemistry exercise	20
3. Quantitative Biology & Population genetics	15
4. Spotting (1 to 5)	15
5. Practical record	10
6. Viva-Voce	10
7. Seminar	10
	Total=100

PRACTICALS EXERCISES

1. **Dissections :**
   1. **Leech** : Reproductive, excretory, nervous and haemocoelomic systems.

2. **Cockroach** : General anatomy, nervous system, and reproductive system.
3. **Crab**: Nervous system.
4. **Scorpion** : Nervous and reproductive systems.
5. **Mollusca** : N. systems of ***Patella***, ***Lamellidens***, ***Mytilus***, ***Sepia*** and ***Aplisia***. General anatomy of ***Aplysia***.
6. C.S. of Arm of starfish.
7. General anatomy of holothurias.
8. Aristotle's lantern of sea urchin and disarticulated parts of Aristotle's lantern.

2. **Permanent Preparations (Mountings)**
   (i) Culture of *Parameciums* and *Amoeba*.
   (ii) *Vorticella, Euglena, Opalina, Balantidium* and *Nyctotherus* from the rectum of frog.
   (iii) Flagellates from the gut of white ant and housefly.
   (iv) *Trypanosomes* in the blood of house rat.
   (v) Collection and study of live *Hydra* and its mounting.
   (vi) Collection, fixation and permanent preparations of trematodes, cestodes and nematodes found in the alimentary canal and other parts of the body of frog and rat.
   (vii) Nephridia of annelids, gills of any molluscs.
   (viii) Trachea of insects, Book lungs of scorpion.
   (ix) Fresh water phyto and Zooplankton.
3. **Museum Specimens:** Identification, classification and distinguishing features of important representatives from various groups (Protozoa to Hemichordata).
4. **Study of Permanent prepared slides** (From Protozoa to Hemichordata:
   Amoeba, Entamoeba, Polystomella, Actinophys, Euglena, Noctiluca, Voluox colony, Trypanosoma, Giardia, Opalina, Nycto therus Balantidium, Vorticella, Monocystis, Plasmodium, Sycon T.S. and L.S. Gemmule, *Obelia* colony, *Obelia* medusa, *Aurelia* tentaculocyst, *Fasciola hepatica* sections through various region of the body, *Hirudinarea* body sections, *Daphnia, Cypris, Cyclops,* T.S. *Peripatus*.
   Larval : Aurelia-Planula, Redia, Cercaria, Meta cercaria, Trochophore, Nauplius, Zoea, Mysis, Phyllosoma, Veliger, Glochidium, Bipinnaria, Ophiopluteus, Echinopluteus, auricularia, Tornaria.

5. Biological Chemistry:

(i) Identification of protein, carbohydrate and lipid in various tissues/body fluids.

(ii) Identification of different kinds of mono-di and polysaccharides 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 and ascorbic acid.
   b. Proteins: Total proteins
   c. Lipids: Phospholipids and cholesterol.
   d. Nucleic acid: DNA and RNA
   e. Enzymes: Acid and alkaline phosphatases

(v) Paper chromatography: Unidimensional chromatography, using amino acids from purified samples and biological materials.

(vi) Paper electrophoresis: Determination of serum proteins through paper electrophoresis.

6. Physiology:

(i) Demonstration of the use and operation of oscilloscope for recording neuroelectric activity and electrocardiogram.

(ii) Kymographic recording of muscle twitch, summation of twitches, clonic contractions, tetanus, fatigue and stair-case phenomenon from the sciatic nerve, gastrocnemius muscle preparation of frog.

(iii) Demonstration of Kymographic recording of the frog's heart beat and the study of the effect of electrical stimulation, hot and cold, drugs, etc.

(iv) Study of spinal and convulsive reflexes in frog

*In case, frogs become available students may be asked to perform the various exercises. Otherwise following **CAL** exercise may be included (please see E-pharm programme)

A. The effect of K+, Ca++, acetyl choline and epinephirne on the isolated heart of frog and conclude your data with the graphic representation.

B. The effect of various doses of acetyl choline and Norephinephrine on blood pressure, heart rate and respiratory rate of the rabbit.

C. The effects of Atropine, Epinephrine, Ephedrine and

Eserine on Rabbit's eyes. And other such exercises can be framed from the E-Pharm software.

(v) Photometric determination of haemoglobin in. blood sample.

(vi) Determination of MCV, MCH, MCHC and colour index of the given sample of blood.

(vii) Demostration of the following in blood: Clotting time, erythrocyte sedimentation rate, haemolysis and crenation.

(viii) Determination of the urea in urine/blood.

(ix) Determination of the glucose in urine.

(x) Radiation uptake in various tissues: Elementary idea or using radioactivity detection instruments.

(xi) Study of digestive enzymes in different parts of the alimentary canal.

7. **Cell Biology:**

(i) Squash and smear preparations of testis of cockroach and grasshopper, aceto-orecin and Fuelgen staining of these preparations.

(ii) Study of mitosis in onion root tip and mammalian bone marrow cells.

(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 an insects or mammal to study the mitochondria.

(v) Preparation of multipolar nerve cell from the spinal cord of a mammal.

(vi) Chromosome counts in cells of the testis of an insect or mammal or cells of the bone marrow of a mammal.

(vii) Study of prepared microscope slides, including those showing various cell types, mitosis, meiosis and giant chromosomes.

8. **Genetics:**

(i) Identification of male and female **Drosophila**.

(ii) Identification of wild and mutant forms of **Drosophila**.

(iii) Monohybrid and dihybrid inheritance in **Drosophila**.

(iv) Simple problems based on Mendelism to be done by the students.

(v) Identifications of blood groups in humans.
(vi) Demostration of sex chromatin.

9. **Statistical Methods in Biology.**
   (i) Preparation of frequency tables and graphs.
   (ii) Calculation of standard deviation, variance and standard error of the mean.
   (iii) Calculation of probability and significance between means using t-test.
   (iv) Plotting the slope, of a line on a graph; calculations of the slope of a line, coefficient correlation and regression.

UGC- List of Practicals (M.Sc. Previous)

1. **Nervous System:** *Crab/ Sepia/ Loligo.*
2. **Mounting:** Nephridium and Spermatheca of Earthworm.
3. **Respiratory System:** Mounting of gills, trachea and book lungs
   PROTOZOA -Gregarines, *Monocystis, Ceratium, Euplotes, Didiniurn, Noctiluca, Radiolaria, Ctenior Opalina.*
   PORIFERA-Sectional view of *Sycon* (T.S., L.S.), *Grantia* (T.S.).
   CNIDARIA-Slides of *Obelia* polyp and medusa, *Pennaria, Aurelia,* Tentaculocytes Museum specimens of *Virgularia, Spongodus, Zoanthus, Favia.*
   HELMINTHES- Slides of *Temnocephala* Museum Specimens of *Ascaris lumbricoides, Taenia solium, Planaria.*
   ANNELIDA- Slides of *Ozonbranches, Glossophonia.* Museum Specimens of *Eunice, Chloehava. Polynoe, Terebella. Eurythoe.*
   ARTHROPODA- Slides of *Cyclops, Daphnia, Chelifer,* section of *Peripatus.* Museum Specimens of *Balanus, Lepas, Palinurus, Uca, Pycna, Hippa, Gongylus, Belostoma. Limulus, Squilla, Eupagurus.*
   MOLLUSCA-Museum Specimens of *Dolobella, Pteria, Nerita, Sanguinolaria, Chicoreus, Ficus, Lambis, Tridacna, Onchidium, Oliva, Murex, Turritella, Bulla, Cardium, Arca.*
   ECHINODERMATA-Museum Specimen of *Linkia, Echinodiscus, Holothuria, Antedon.*
   MINOR PHYLA-Slides of *Bugula, Plumatalla, Cristatella, Pectinella, Museum* Specimen of *Phoronis, Dendrostoma.*
   LARVAE-*Aurelia-Planula,* Redia, Cercaria, *Filiform of strongybides,* Trochopore, Nauplius, Zoea, Mysis, Phyllosoma, *Trilo-*

bite larvae of Limulus, *Antedon*, Veliger, Bipinnaria, *Ophio* and *Echinopluteus, Auricularia*, tornaria.

List of Practicals Exercises As Suggested by UGC for M.Sc. (Previous) Zoology

1. Composition assessment of taxonomic diversity/biodiversity in a habitat (eg. grassland, aridland, wetland, etc.)
2. Influence of climatic conditions on taxanomic diversity in a given habitat.
3. Preparation of models showing the status of certain taxa or species in a particular habitat.
4. Demonstration of "DNA ladder" formation during apoptotic death.
5. Preparation of liposomes.
6. Estimation of gene and genotypic frequencies in light of Hardy-Weinberg Law based on facial traits, blood group data (ABO), PTC data dermatoglyphics in a large sample of human population or a classroom sample.
7. PC based simulation models for effect of micro-evolutionary forces on allele frequency.
8. Demonstration of chromosomal polymorphism, isozyme polymorphism in some insect populations.
9. Morphological variation and its genetic basis in humans, insects, plants or other taxa.
10. Construction of phylogenic trees based on protein, immunological or molecular data (mt DNA, RFLP data)(PC based simulation).
11. Demonstration of effect of natural and artificial selection on gene frequencies in Drosophila, wild and mutant strains.
12. Demonstration of Sewall Wright effect in small samples of Drosophila population.
13. Study of quantative characters in Drosophila and estimation of heritability.
14. Numericals based on H-W Law, Natural selection forces changing the frequencies, in natural populations.
15. Demonstration of density dependent selection in plant or animal population.
16. Demonstration of reproductive isolation in Drosophila, species hybridization.

17. Demonstration of mating behaviour in wild and mutant strains of Drosophila.
18. PC based simulations of molecular phylogenetics.
19. Estimation of genetic identity and genetic distance from allele frequency data in several populations.
20. Colorimetric estimation of glucose, protein, RNA, DNA.
21. Absorption spectrum of any coloured solution of a substance.
22. Light microscopic examination and preparation of tissue sections.
23. Use of different types of microscopes.
24. Sample preparation for SEM and TM.
25. Growth curve for *E.coli/Neurospora crassa.*
26. Bioassays for hormones.
27. Subcellular fractionation of rat liver.
28. Preparation of different cell types-(eg.: Hepatic parenchymal cells, adipocytes, macrophages, neuronal cells etc.)
29. Computer software use for computational tasks, data presentation tasks, design tasks.
30. Separation of proteins on SDS-PAGE.
31. Determination of molecular weights of proteins by SDS-PAGE and denistometric scanning.
32. Separation of amino acids by paper chromatography and TLC.
33. Surgical techniques such as adrenalectomy, thyroidectomy, castration, etc. to be done on rats or mice.
34. Isolation of genome DNA
35. Southern blotting.
36. RFLP analysis.
37. Isolation of RNA.
38. Isolation of polyA + RNA.
39. Northern blotting.
40. In-vitro translation.
41. In-vivo translation.
42. Polymerase chain reaction.
43. Restriction digestion of DNA.
44. Agarose gel electrophoresis of DNA.
45. Isolation of DNA fragments from gels.
46. Ligation of DNA fragments.
47. Appearance of heat shock proteins-demonstration using electrophoresis.

48. Comparision of RBC in different groups of vertabrates.
49. Oxygen consumption in aquatic animals under stress.
50. Determination of respiratory quotient in a terrestrial animal and effect of temperature.
51. Toxicity test-LC 50.
52. Pattern of Nitrogen excretion in an amphibian during development.
53. Nervous system of a crab.
54. Mounting of nephridium and spermatheca in earthworm.
55. Mounting of gills, trachea and book lung of scorpion.
56. Experiments on perfused heart of frog using kymograph/oscilloscope.
57. Experiments with Gilson respirometer.
58. To study the effect of temperature on plasma protein: appearance of new protein bands to be studied with gel electrophoresis under temperature stress.
59. Comparision of RBC and WBC number in different groups of vertabrate under different environmental conditions.
60. To study the rate of oxygen consumption by aquatic animals under various environmental stresses.
61. Determination of respiratory quotient of an air breathing animal at different temperature.
62. To study the changes of blood glucose level under various environment stresses in a vertabrate species.
63. Effects of stress of light in chlorophyll pigment of a plant.
64. Estimation of daily intake, EC5O and LC 5O against mosquito larvae.
65. Study of Toxicity of given chemical on analyse activity.
66. Sperm motility tests and analysis.
67. Histology of gonads.
68. Bioassay for androgens, estrogens and pituitary gonadotrophins.
69. Histochemical demonstration of steroid dehydrogenase.
70. Biochemical analyses of semen.
71. *in vitro* fertilization using zona denuded hamster eggs/mice/fish/frogs.
72. 100Cytogenic and molecular methods in sex determination.

Note

About 50% (32) is mandatory to opt especially for M.Sc. Pre-

vious of above exercises from the UGC recommended curiculum. While selecting these 50% exercises, care should be taken to choose at least 2 to 5 exercises as representatives from each of the theory paper.

It is further stated that in addition to the foregoing number, few exercises (minimum up to 8) may be added by the department or Institution itself as per the needs of local surroundings or facilities available. Such exercises shall be based on actual data obtained by candidates through field studies or experimental work. The candidates shall have to maintain a complete record of the work done.

The total number of practical exercises should he as many as the departmental potential can cater.

Alternative practical approaches and educational aids should also form an active part of laboratory system, which could replace animal use. The availability and use of these alternative approaches is to strengthen the learning process.

The adoption of alternative laboratory methods should keep the content of the syllabus upto date in the light of recent progress of technological developments. It should also be taking care of ethical issues. It shows respect for student ethical concerns and grants animals their integrity and freedom from harm.

Teachers and students are encouraged to adopt the following alternatives, which are wide ranging.

MODELS AND SIMULATORS: Models or mechanical simulators can be invaluable for the study of anatomy and physiology. They range from simple, inexpensive models to computerised equipments.

COMPUTER SIMULATION: Computer alternatives may be highly interactive and incorporate other media, such as high quality graphics, film and sound, often using CDROMS and videodisks. They may be based on actual experimental data or be generated from classic teaching objectives. therfore, teachers are encouraged to provide at least one small computer in each laboratory and install Computer Assisted Learning Programmes. This should be made mandatory at least for postgraduate classes.

SELF-EXPERIMENTATION (mainly for Postgraduate classes): It may be persued in the Optional paper in M.Sc. Final

with the help of concerning teachers in the ongoing stream.

OBSERVATIONAL AND FIELD STUDIES (FOR Postgraduate classes)

There is an unlimited amount of alternative practicals that can be carried out using observational and other work in the field. Wild and companion animals and of course humans all other opportunities for designing non-in-vasive, non-harmful practical work for the study of Zoology, Anatomy, Physiology, Ethology, Epidemiology and Ecology. Such fieldwork may also encourage students to recognize their social and environmental responsibilities.

1. M.Sc.FINAL

3 Hours Duration **100 Marks (each paper)**

Paper I	Biology of Chordates
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

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 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

1. Origin and outline classification of the chordates. 3
2. Interrelationships of Hemichordata, Urochordata and Cephalchordata and their relations with other deuterostomes. 5
3. Life histories of sessile and pelagic tunicates, *Ascidia, Pyrosoma, Salpa. Doliolum* and *Oikopleura.* 8
4. Neoteny 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 of the Elasmobranchii. Holocephali. Dipnoi and Crosspterygii.
   - 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 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 adaptations.
   - 5.12 Origin of Mammals.
   - 5.13 Primitive Mammals (Prototheria and Metatheria)
   - 5.14 A general survey of the main radiations in eutherian, 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 5
8.1 Structural and physiological changes during metamorphosis.
8.2 Endocrine control of metamorphosis.

9. Regeneration 5
9.1 Types 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 cells for regenerations and differentiation.

Suggested Reading Material

1. Alexander, R.M. : The Chordata, Cambridge University Press, London.
2. Barrington, E.J.W. : The Biology of Hemichordata and Protochordata, Olter and Boyd, Edinbourgh.
3. Bourne, G.H. : The Structure Functions of Nervous Tissues Academic Press, New York.
4. Carter, G.S. : Structure and Habit in Vertebrate Evolution Sedwick and Jackron, London.
5. Eccles, J.C.: The understanding of the Brain, McGraw Hill Company, New York.
6. Kingsley, J.S. : Outlines of Comparative Anatomy of Vertebrates Central Book Depot, Allahabad.
7. Kent, C.G. : Comparative Anatomy of Vertebrates.
8. Malcom Jollie : Chordata Morphology, East-West Press Pvt. Ltd., New Delhi.
9. Milton, H. : Analysis of Vertebrate Structure, John Wiley and Sons, Inc., New York.
10. Monielli, A.R. : The Chordates, Cambridge University Press, London.
11. Smith, H.S. : Evolution of Chordata Structure, Hold Rinehart and Winstoin, Inc., New York.
12. Sedgwick, A.A : Text Book of Zoology, Vol-II

13. Tansley, K. : Vision in Vertebrate, Chapman and Hall Ltd., London.
14. Torrey, T.W. : Morphogenesis of Vertebrates, John Wiley & Sons, New York.
15. Walters, H.E. and Sayles, L.D. : Biology of Vertebrates, Macmillan and Co., New York.
16. Romer, A.S. : Vertebrate Body, W.B. Saunders Company, Philadelphia.
17. Young J.Z. : Life of Vertebrates, The Oxford University Press, London.
18. Colbert, E.H. : Evolution of the Vertebrates, John Wiley & Sons, Inc., New York.
19. Romer, A.S. : Vertebrate Palentology, University of Chicago Press, Chicago.
20. Clark, W.K., : History of Primates, University of Chicago Press, Chicago.
21. Weichert, C.K. and Presch, W. : Elements of Chordate Anatomy, MacGraw Hill Book Company, New York.
22. Messers, H.M.: An Introduction of Vertebrate Anatomy.
23. Montagna, W. : Comparative Anatomy, John Wiley & Sons, Inc., New York.
24. DeVeer, S.G. : Embryos and Ancestors, Claredon Press, Oxford.
25. Andrew, S.M. : Problems in Vertebrate Evolution, Academic Press, New York.
26. Waterman, A.J. : Chordata Structure and Function, MacMillan Co., New York.
27. Joysey, K.A. and Kemp, T.S. : Vertebrate Evolution, Oliver and Boyd, Edinbourgh.
28. Lovtrup, S. : The Phylogeny of Vertebrate, John Wiley & Sons, London.
29. Barbiur T. Hongton : Reptiles and Amphibians : 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.

M.Sc. FINAL (ZOOLOGY)

PAPER-II : ENVIRONMENTAL BIOLOGY AND ETHOLOGY

3 hours duration 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.

Unit I- Environmental Biology

1. Interactions between environment and biota 5
   - 1.1 Concept of habitat and ecological niches.
   - 1.2 Limiting factors.
   - 1.3 Energy flow, food chain, food web and trophic levels, ecological pyramids.
   - 1.4 Biotic community: Concept, structure, dominance, fluctuation and succession.
   - 1.5 Various nutrient cycles in nature.
2. Ecosystem dynamics and management 6
   - 2.1 Complexity, stability and homeostasis of ecosystems.
   - 2.2 Functional aspects and productivity concept.
   - 2.3 Niche, ecotone, and overlapping of niches.
   - 2.4 Character displacement, speciation and extinction.
3. Environmental impact assessment 5
   - 3.1 Environmental pollution.
   - 3.2 Population and impact of urbanization.
4. Principles of conservation: Conservations strategies 5
   - 4.1 Various natural resources.
   - 4.2 Present status and future needs.
   - 4.3 Management.
   - 4.4 Biodiversity of India and Rajasthan and their management.

5. Prospects and strategies for sustainable communities. 2
6. Organisation and dynamics of ecological communities 7
   - 6.1 The habitat approach.
   - 6.2 A detailed knowledge of communities of fresh water, marine, terrestrial and esturine areas with respect to
     - 6.2.1 Extent,
     - 6.2.2 Zonation,
     - 6.2.3 Environment,
     - 6.2.4 Biota,
     - 6.2.5 Adaptations
7. The ecological outlook 5
   - 7.1 Applied human ecology
   - 7.2 Radiation (electromagnetic and ionizing) and environment
   - 7.3 Climatic changes (El Nino and La Nina)
   - 7.4 Space ecology
   - 7.5 Human future

Unit - II: Ethology

1. **Introduction to the study of animal behaviour** 4
   - 1.1 Aims of behavioural research
   - 1.2 Diversity of animal behaviour
   - 1.3 Ethology: Historical perspective
   - 1.4 Milestones in the study of animal behaviour
2. **Concepts of ethology** 6
   - 2.1 Fixed action patterns
   - 2.2 Action specific energy
   - 2.3 Sign stimulus
   - 2.4 Innate releasing mechanism.
   - 2.5 Learning and imprinting.
3. **Proximate mechanisms in behaviour / neuroethology** 6
   - 3.1 Introduction to neuroethology : Cellular mechanisms in behaviour
   - 3.2 Neural basis of sensory perception
   - 3.3 Central neural processing
   - 3.4 Neural basis of motor responses
   - 3.5 Brain and behaviour
   - 3.6 Behavioural endocrinology
4. **Ultimate mechanisms in behaviour and behvioural ecology** 6
   - 4.1 Example of agonistic interactions among conspecifics.

4.2 Hardy-Weinberg equilibrium and dispersal and inbreeding.
4.3 Gametes and the evolution of mating and evolution of mating systems.
4.4 Evolution of altruism and eusociality.
4.5 Human socio-biology, human ethology.
4.6 Mating and courtship behaviour.

5. Spatial patterns, navigation and communication 6

5.1 Orientation, navigation, migration and channels of communication.
5.2 Physical properties of signals.
5.3 Field studies on primates : A preliminary knowledge.
5.4 Animal communication.
5.5 Biological rhythm and its hormonal control.
5.6 Pheremones; primer and releaser effects.

6. Social organizational orientation 7

6.1 Social organizations and its advantages.
6.2 Evolution of social systems.
6.3 Social groups of bees and monkeys.
6.4 Learing:
6.4.1 Introduction, definition and types.
6.4.2 Habituation, trial and error and conditioning.
6.5 Bird song learing behaviour in the context of Tinbergen's 4 aims.
6.6 Parental Care.
6.7 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. Jorgension, S.E. : Fundamentals of Ecological Modeling, Elsevies.
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, Johnwiley & 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.

Ethology

11. Rof, D.A. : The Evolution of Life Histories, Chapman and Hall, London, U.K.
12. Alcock, J. : Animal Behaviour: An Evolutionary Approach, Sinauer Assoc. Sunderland, Mass, USA.
13. Bradbury, J.W. and Vehren camp, S.L. : Principles of Animal Communications, Sinauer Assoc. Sunderland, Mass, USA.
14. Clutton-Brock, T.H. : The Evolution of Parental Care Princeton Univ. Press, Princeton, USA.
15. Eobi-Eibesfeldt, Holt, I : Ethology, the Biology of Behaviour, Rinehart and Winston, New York.
16. Gould, J.L. : Mechanism of Evolution of Behaviour,.
17. Hauser, M. : The Evolution of Communication, MIT Press, Cambridge, Mass, USA.
18. Hinde, R.A. : Animal Behaviour : A Synthesis of Ethology and Comparative Psychology, McGraw Hill Company, New York.
19. Krebs, J.R. and Davis, N.V. : Behavioural Ecology, Blackwell Oxford, U.K.
20. Wilson, E.O. : Sociobiology : The New Synthesis, Harward University Press, Cambridge, Mass, USA.

PAPER-III : GENES AND DIFFERENTIATION

3 Hours Duration ***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. 7
   1.1 Problems of developmental biology.
   1.2 Developmental patterns in metazoans.
   1.3 Development in unicellular eukaryotes.
2. Creating multicellularity 5
   2.1 Cleavage types.
   2.2 Comparative account of gastrulation.
3. Early Vertebrate development 6
   3.1 Neurulation and ectoderm.
   3.2 Mesoderm and endoderm.
4. Cytoplasmic determinants and autonomous cell specification 8
   4.1 Cell commitment and differentiation.
   4.2 Cell specifications in nematodes
   4.3 Germ cell determinants.
   4.4 Germ cell migration.
   4.5 Progressive cell–cell interaction and cell specification fate.
5. Body Axes 5
   5.1 Establishment of body axes in mammals and birds.
   5.2 Proximate tissue interactions.
   5.3 Genetics of axis specifications in drosophila.
6. Homeobox concept in different phylogenetic groups. 4
7. Tetrapod limb development. 3
8. Hormones as mediators of development. 6
   8.1 Amphibian metamorphosis.
   8.2 Insect metamorphosis.
   8.3 Ovarian luteinization and mammary gland differentiation.
9. Environmental evolution and animal development 8
   9.1 Environmental cues and effects.
   9.2 Malformations and distruptions.
   9.3 Changing evolution through development modularity.
   9.4 Developmental constraints.
   9.5 Creating new cell types-basic evolutionary mystery.
10. Biology of sex determination 6
   10.1 Chromosomal sex determination - Mammals and Drosophila.
   10.2 Testis determination genes.
   10.3 Ovarin development.

10.4 Secondary sex determination in mammals.
10.5 Environmental sex determination.

11. Cell diversification in early embryo 6
    11.1 Xenopus blastomeres.
    11.2 Morphogen gradients.
    11.3 Totipotency & Pleuripotency.
    11.4 Embroyonic stem cells.
    11.5 Renewal by stem cells-epiderms.
    11.6 Skeletal muscle regenration.
    11.7 Connective tissue cell family.
12. Hemopoietic stem cells 6
    12.1 Stem cell disorders.
    12.2 Blood cell formation.
    12.3 Bone marrow transplants.
    12.4 Gene therapy.

Suggested Reading Material

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

PAPER-IV : TOOLS AND TECHNIQUES IN BIOLOGY

3 Hours Duration ***Max. Marks 100*** ***Periods : 70***

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.

Section A : Tools

1. Principles and application of 10
    1.1 Light Microscopy and micrometery.
    1.2 Phase contrast microscopy.
    1.3 Interference microscopy.
    1.4 Polarized microscopy.

1.5 Fluoresence & epifluorescence microscopy.
1.6 Transmission electron microscopy.
1.7 Scanning electron microscopy.
1.8 Confocal scanning and deconvolution microscopy.

2. Principles and application of 10
2.1 Ultracentrifugation: Differential and density gradient.
2.2 Electrophoresis: Various media for electrophoresis and various types such as paper, agrose, PAGE, submerged DNA electrophoresis, pulse chase electrophoresis, isoelectro-focussing points and capillary electrophoresis.
2.3 Chromatography: various types such as paper, TLC, GLC, HPLC, ion-exchange and affinity chromatography.
2.4 Freeze techniques; freeze-drying, freeze substitution, freeze fracture and freeze itch.
2.5 X-Diffraction.
2.6 Lambert-Beers Law and colorimetery & spectrophotometery fluorescence, U.V., N.M.R., O.R.D./CD, ESR, IR, Atomic absorption, plasma emission spectrophotometery.
2.7 Flow cytometery/Flouresence activated cell sorter.

3. Principles and application of radiation techniques in Biology 10
3.1 Radiation dosimetry.
3.2 Radioisotopes and half life of isotypes.
3.3 Tracer techniques in biology.
3.4 Cerenkov radiation.
3.5 Liquid scintilation.
3.6. Autoradiography.

Section B : Techniques

1. Assay 2
1.2 Definition and criteria of reliability.
1.2 Chemical assays.
1.3 Biological assays-in vivo and in vitro assays.

2. Principles of cytological and cytochemical techniques 5
2.1 Fixation, chemical basis of fixation by formaldehyde, gluteraldehyde, chromium salts, mercury salts , osmium salts, alchol and acetone.
2.2 Chemical basis of staining of carbohydrates, proteins, lipids and nucleic acids.

3. Principles and techniques of 8

3.1 Nucleic acid hybridization and cot curve.
3.2 Sequencing of proteins and nucleic acids.
3.3 Blotting techniques (Southern, Northern and Western).
3.4 Dot and Slot blots.
3.5 Biotinylated DNA probe.
3.6 Polymerase chain reaction (PCR).
3.7 Screening of genomic and cDNA libraries.

4. Principles and techniques of genetic engineering 8
4.1 Basic techniques.
4.2 Cutting and joining of DNA molecules.
4.3 Changing genes: site directed mutagenesis.
4.4 Analysis of DNA sequences.
4.5 Cloning strategies, gene library and cDNA.
4.6 DNA transformation techniques and their application in agriculture, health, medicine and industry.
4.7 Introducing genes in animal cells.
4.8 Application of recombinant DNA technology.
(a) Recombination, selection and screening
(b) Nucleic acid probes and their application.
(c) Impact of recombinant technology.
4.9 Hybridoma technology.
4.10 Transgenic animals.

5. Embryo technology 10
5.1 Superovulation, cryopreservation of spermatazoa.
5.2 *In Vitro* fertilization.
5.3 Embryo sexing.
5.4 Chimera formation.
5.5 Gene transfer through embryo transgenesis.
5.6 Embryo transfer.
5.7 Assisted reproductive technologies.
5.8 Prenatal diagnosis and genetic counselling.

6. Cell Culture techniques 4
6.1 Design and functioning of tissue culture laboratory.
6.2 Cell proliferation measurements.
6.3 Cell viability testing.
6.4 Culture media preparation and cell harvesting methods.

7. Cryotechniques 3
7.1 Cyropreservations for microscopy.

7.2 Cyrotechniques for microscopy

Suggestied Reading Material

1. John R.W. Masters : Animal cell Culture. A Practical Approach, IRL, Press.
2. Robert Brown : Introduction to Instrumental Analysis, McGraw Hill, International Education.
3. Wilson, K., Goulding, K.H. : A Biology Guide to Principles and Techniques of Practical Biochemistry, ELBS edition.

M.Sc. Final : List of Practical Contents (General)

1. Dissections

(a) **Major dissections**

(i) Cranial nerves of *Wallago attu.*
(ii) Cranial nerves of *Rana tigrina*
(iii) Neck nerves of Rat
(iv) Reproductive organs of Rat

(b) **Minor dissections**

(i) Accessory respiratory organs of *Heteropnuestes fossilis*
(ii) Labrinthin organs of *Anabas testudens*
(iii) Internal ear of *Scoliodon*

2. Museum Specimens

Lower Chordates : *Salpa* asexual and sexual stage Doliolum oozoid, *Botrylus, Herdmania, Amphioxus*

Pisces : *Petromyzon, Myxine, Rhinobatus, Pristis, Trygon, Chimaera, Polydon, Acipenser, Amia, Lepidosteus, Protopterus, Lepidosiren, Neoceratodus, Notopterus, Exocoetus, Echeneis, Pleuronectes, Mestacembelus, Diodon, Tetradon, Ostracion, Lophis, Syngnathus, Hippocampus, Anguilla, Labeo, Ophiocephalus.*

Amphibia : *Ichthyophis, Necturus, Proteus, Ambystoma, Axolotal, Salamender, Siren, Alytes, Pipa, Buto, Hyla, Rhacophorus, Rana.*

Reptilia : *Testudo, Chelone, Sphenodon, Calotes, Hemidactylus, Phyrosoma, Draco, Varanus, Chameleon, Cobra, Hydrophis,* Rattle snake, Viper, Pit viper, Krait, Eryx, Gavialis.

Aves : Tailor bird, Indian Koel, Jungle fowl, *Pavo Columba, Psittacula,* Wood pecker, *Bubo, bubo* (Horned owl) *Archaeopteryx*, Flamingo.

Mammals : *Ornithorhynchus, Echidna, Macropus,* Hedgehog, Manis, Loris, Bat, Mangoose, Hystrix, Otter,

3. Microscopic slides :

Lower chordates : *Herdmania* spicules, *Herdmania* tadpole larva, *Amphioxus* T.S. passing through oral hood, pharynx, testes and ovary, intestine and caudal regions. Ammocoete larva whole mount.

Pisces : Placoid scale, cycloid sacle, ctenoid scale.

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, pituitary gland, lung, bone, spinal cord. Blood smear, imple cuboidal epithelim, simple columnar, epithelium, simple squamour, epithelim, adipose tissue, reticular tissues.

4. Comparative Osteology :

Comparative account of Axial and appendicular skeletons of Frog, Varanus, Fowl and Rabbit. *Both Articulated and disarticulated.*

5. Exercises in Tools and Techniques

(i) Operation of various types of microscopes.

(ii) Use of Phase-contrast microscope.

(ii) Use of flourescence microscope and demonstration of nucleic acid by acridine orange or ethidium bromide.

(iv) Preparation of tissue for TEM.

(v) Tissue homogenization and fractionalion by differential

centrifugation for isolation of mitochondria, nuclic and cytosol and use of marker enzymes for assessment of the purity of the components.

(vi) Demonstration of GLC, atomic absorption spectro photometer CASA etc.

(vii) Standardisation of occulometer and measurements of tubular diameter, Cell heights, nuclear diameters etc.

(viii) Surgical techniques : Adrenalectomy, thyroidectomy, castration etc.

(ix) Electrophoresis

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

Practicals (M.Sc. Final, General Papers)

Scheme of Practical Examination

Duration : 6 hrs. **Max. Marks–100**

	Exercise	Marks
1.	Major dissection	12
2.	Minor dissection/Mounting	5
3.	Ethology	6
4.	Environmental Biology	8
5.	Tools and Techniques	8
6.	Embryology	7
7.	Spotting (No. 1-8)	24
8.	Practical record	10
9.	Viva-Voce	10
10.	Seminar	10
		Total –100

Note:

1. With reference to dissection, candidates must be well-versed with technique of flag labelling and black paper insertion as the case may be for a clear illustration.
2. With reference to whole mounts and museum specimens, in case of unavailability of certain animal types, diagrams, photographs, models etc. should be substituted. Study will include classification, (upto classes) with diagnostic characters and comments.
3. Candidate will keep a record of all work done in the practical

class and it will be submitted for inspection at the time of the practical examination.

4. The detailed methodology may be asked to write wherever necessary and seperate marks may be allocated for it.

Special Paper for M.Sc. Zoology (Final)

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

1. **Cancer Biology**
2. **Cell and Molecular Biology**
3. **Developmental Biology**
4. **Endocrinology**
5. **Entomology**
6. **Environmental Biology**
7. **Fish Biology**
8. **Radiation Biology**
9. **Reproductive Biology**

1. CANCER BIOLOGY

PAPER-V: NATURE OF CANCER

3 Hours Duration ***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. Introduction: Cancer as a cellular disease.
   - 1.1 Historical perspectives.
   - 1.2 Cancer causation.
   - 1.3 Cancer biology.
   - 1.4 Cancer treatment.
   - 1.5 Death due to cancer.
2. Occurrence of cancer.

2.1 Present day status of cancer in India.
2.2 Status of cancer occurrence in different parts of the world.
2.3 Cancer of different sex.
2.4 Cancer of different age groups.

3. Tumor classification.
   3.1 Benign and malignant tumors.
   3.2 Sarcoma and carcinoma.
   3.3 Leukemia and lymphoma.
   3.4 Ascites tumors.
   3.5 Teratocarcinoma.
4. Etiology of cancer
   4.1 Staging and grading of cancer.
   4.2 *In vitro* cell transformation.
   4.3 Apoptosis.
5. Cancer cell:
   5.1 Structural and ultrastructural profiles.
   5.2 Biochemical properties.
   5.3 Behaviourial properties.
6. Genetic basis of cancer:
   6.1 Basic concepts of cancer genetics.
   6.2 Relationship between cancer incidence and age.
   6.3 Cellular and genetic basis of cancer.
   6.4 Types of genetic risk factors for cancer.
   6.5 Chromosomal abnormalities in tumor.
   6.6 Heritable cancer and tumor suppressors.
7. Cancer cell growth patterns and cell kinetics
   7.1 Tumor growth.
   7.2 Cell cycle.
   7.3 Cell proliferation in tumor tissue.
   7.4 Experimental tumors.
   7.5 Human tumors.
   7.6 Cell proliferation, prognosis and therapies.
8. Metastasis:
   8.1 Introduction.
   8.2 Metastatic process.
   8.3 Metastatic ability of tumor cell population.
   8.4 Properties of metastatic cells.
   8.5 Genetic basis of metastasis.

Paper-VI: CAUSATION, PREVENTION AND CURE OF CANCER

3 Hours Duration ***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. Introduction:
   - 1.1 Historical aspects.
   - 1.2 Environmental factors and cancer.
     - 1.2.1 Tobacco, Alcohol, diets, occupational exposures, hormones and other exposure.
   - 1.3 Specific types of cancer: Hepatocellular carcinoma, Melanoma, Breast cancer, lung cancer.
2. Causation of cancer:
   - 2.1 Hereditary cancer.
     - 2.1.1 Introduction.
     - 2.1.2 Xeroderma pigmentosum.
     - 2.1.3 Fanconis Anaemia.
     - 2.1.4 Bloom syndrome.
     - 2.1.5 Ataxia telangiectasia.
     - 2.1.6 Retinoblastoma.
   - 2.2 Virus and cancer.
     - 2.2.1 Introduction.
     - 2.2.2 Viruses and oncogenes.
     - 2.2.3 Historical perspectives.
     - 2.2.4 Tumor virus and human cancer.
     - 2.2.5 Retrovirus.
     - 2.2.6 DNA tumor viruses.
   - 2.3 Chemical carcinogenesis.
     - 2.3.1 Introduction.

2.3.2 Biological characteristics of chemical carcinogenesis.
2.3.3 Initiation, promotion and progression of carcinogenesis.
2.3.4 Assay methods for chemical carcinogens.
2.3.5 Chemical carcinogens in human cancer causation.
2.4 Radiation carcinogenesis.
2.4.1 Cell transformation.
2.4.2 Mechanism of radiation cell transformation.
2.4.3 Radiation carcinogenesis in animals.
2.4.4 Human data on radiation carcinogenesis.
2.5 Hormones and cancer.
2.5.1 Introduction.
2.5.2 Hormone production by tumors.
2.5.3 Hormone and cancer causation.
2.5.4 Hormones and cancer treatment.

3. Nutrition and cancer.
3.1 Cancer risks form naturally occurring carcinogens in food, food contaminants, additives.
3.2 Micronutrients in diet: Protein, carbohydrate, fat, fibers.
3.3 Micronutrients in diet: Mineral, salts, green yellow vegetables, fruits.

4. Therapy of cancer.
4.1 Surgical removal.
4.2 Chemotherapy
4.3 Radiotherapy.
4.4 Immunotherapy.
4.5 Hyperthermia.
4.6 Management of therapis of cancer.

5. Prevention of cancer.
5.1 Primary prevention: Education, motivation and legislation.
5.2 Secondary prevention.
5.2.1 Detection of precancerous and early cancerous lesions in body.
5.2.2 Chemoprevention.

6. Oncogenes:
6.1 Introduction.
6.2 Detection of oncogenes in human cancer cells.
6.3 Activation of oncogenes.

6.4 Antioncogenes.

CANCER BIOLOGY

Time : 5 Hours *Max.Marks 100*

Scheme of practical Examination and Ditribution of the marks:

1.	Preparation and comments on chromosomal aberrations, induced by caroinogenes.	15
2.	Preparation and comments on micronuclei induced by carcinogens.	15
3.	Microtomy and Pathological study	20
4.	Indentification and comments on spots (10) : Slides of cancer	20
5.	Viva-Voice	10
6.	Project work on Tumor induction in mice/rat. + one project seminar	20
	Grand Total	**100**

2. CELL AND MOLECULAR BIOLOGY

PAPER - V

3 Hours Duration *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 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

1. Biomembranes

1.1 Phospholipids; as main lipid constituents

1.2 Cytosolic and exoplasmic face of biomembranes.

1.3 Universality of biomembranes

1.3.1 Difference in phospholipid composition in two membrane leaflets.

1.3.2 Intrinsic and extrinsic proteins.
1.3.3 Integral and glycolipids.
1.3.4 Mobility of lipids and integral proteins in biomembrane.
1.3.5 Fluidity of biomembranes.
1.3.6 Cell Junctions (Gap. tight and demosomes etc.)

2. Transport across cell membrane

2.1 Diffusion of small molecules.
2.2 Osmosis and water channels.
2.3 Uniporter-catalyzed transport. Difference between uniport-catalyzed transport and passive diffusion. GLUT-i transport and its kinetics.
2.4 Intracellular ion environment and membrane electric potential.
2.5 Active transport. P-class ion pumps. F-class and V-class ion pumps and ABC superfamily. Plasma membrane Ca2+AT Pase pump. Muscle Ca2+ AT Pase pump and Na+/K+ AT Phase pump.
2.6 Cotransport by symportors and antiporters.
2.7 Transport across epithelia

3. Cytoskeleton:

3.1 Microfilaments
3.1.1 Actin cytoskeleton G-actin and F-actin and structural and functional polarity. Cortical actin network, erythrocytic cytoskeleton and platelet cytoskeleton.
3.1.2 Actin bundle support projecting fingers of membrane.
3.1.3 Dynamics of actin assembly Actin polymerization. Toxins effect on actin monomer - polymer equilibrium stabilization of actin filaments by actin capping protein. Movement by actin polymerization
(a) Intracellular bacterial and viral movements
(b) Actin polymerization at the leading edge of moving cells
3.1.4 Myosin
(a) Structure and mechanism of movement with actin
(b) Conformational changes in myosin during movement

3.2 Microtubules
- 3.2.1 Microtubules structure and microtubule assembly from organizing centers.
- 3.2.2 Microtubule dynamics.
- 3.2.3 Microtubule associated proteins (MAPs) and cross-linking of microtubules

3.3 Microtubules and mitosis
- (a) Centrosome duplication.
- (b) Kinetochore and force for poleward chromosome movement
- (c) Organization of spindle pole and orientation of assembly
- (d) Formation of poles and capture of chromosomes
- (e) Kinetochore and force of poleward chromosome movement
- (f) Astral microtubules and cytokinesis
- (g) Microtubules and plant cell formation.

3.4 Kinesin and Dynein.

3.5 Cell movements:
- (a) Intracellular transport: Role of Kinesin and Dynein, micotubule tracks and intracellular membrane vesicles.
- (b) Amoeboid movements.
- (c) Second messengers and signal transduction pathways for coordination of migration of cells.

4. Cilia and Flagella

4.1 Structure and movements
- (a) Sliding of outer doublet.
- (b) Dynein sliding forces in axonemes.
- (c) Dynein and exonemal bending.
- (d) Dynein regulatory complex.

5. Cell–Cell Signalling

5.1 Endocrine, paracrine and autocrine signaling.

5.2 Receptor proteins- Cell surface receptors and intracellular receptors.

5.3 Cell surface receptors-G-protein coupled receptors, ion channel receptors, tyrosine kinase-linked receptors and receptors with intrinsic enzymatic activity.

5.4 Second messenger System - cAMP and IP3, DAG.

5.5 MAP kinase pathways.
5.6 Signaling from plasma membrane to nucleus (a) CREB links CAMP signals to transcription. (b) MAP kinase.

6. Signal - Mediated transport through Nuclear Pore
6.1 Nuclear Pore Complex.
6.2 Nuclear Exports signals and transport of cargo proteins from nucleus to cytosol.
6.3 Nuclear localization signals and transport of cargo proteins from cytoplasm to nucleus

7. Cell–Cell adhesion and communication
7.1 Cadherin mediated Ca2+ dependent homophilic cell–cell adhesion.
7.2 N-CAMs mediate Ca2+ independent homophilic cell–cell adhesion.
7.3 Cadherin containing junctions connect cells.
7.4 Gap junctions and connexin.

8. Cell matrix adhesion
8.1 Interins-in cell matrix and cell-cell interaction.
8.2 Integrin and cell to substratum attachment.
8.3 Collagen-Basic structure and assembly.
8.4 Non-collagen components of extracellular matrix (Laminin, fibronection and cell surface proteoglycans).
8.5 Plant cell wall.
8.6 Auxin and cell expansion.
8.7 Cellulose fibril synthesis and orientation.
8.8 Plasmodesmata

9. Cell cycle
9.1 Bacterial cell cycle (Helmstetier - Cooper or I+C+D model).
9.2 Partition and cytokinesis.
9.3 Eukaryotic cell cycle - Gl.S. G2 and M phases.
9.4 Cell cycle and check points.
9.5 Molecular basis of cell cycle regulation.
(a) Cyclins and cyclin - dependent kinases.
(b) Regulation of CDK cyclin activity.

10. Cancer.
10.1 Tumor cells and onset of cancer.
10.2 Proto-oncogenesis and tumor suppressor genes.
10.3 Mutation causing loss of cell cycle.

10.4 Mutations affecting genome stability.

11. Aging: The biology of senescence

11.1 Maximum life span and life expectancy.

11.2 Causes of aging

(a) General wear and tear and genetic instability.

(b) Free radicals, oxidative damage and antioxidants.

(c) Telomerases and aging.

12. Cell Death

12.1 Apoptosis and necrosis.

12.2 Apoptosis-its characteristics.

12.3 Genes involved in apoptosis.

12.4 Identification of apoptosis.

13. Molecular structure of genes and chromosomes

13.1 Molecular definition of gene.

13.2 Chromosomal organization of genes and non-coding DNA.

13.3 Mobile DNA.

13.4 Functional rearrangements in chromosomal DNA.

13.5 Organizing cellular DNA into chromosomes.

13.6 Morphological and functional elements of eukaryotic chromosomes.

14. Genetic analysis in cell biology

14.1 Mutation: Type and causes.

14.2 Isolation and analysis of mutants.

14.3 Genetic mapping of mutations.

14.4 Molecular cloning of genes defined by mutations.

14.5 Gene replacement and transgenic animals.

15. Regulation of Gene Expression

15.1 Operon concept.

15.2 Catabolic repression.

15.3 Positive and Negative regulation.

15.4 Inducers and corepressors.

15.5 Regulation by attenution: *his* and *trp* operons

16. DNA binding propeins and gene regulation

16.1 DNA binding domains.

16.2 Homeodomain proteins.

16.3 Zinc finger proteins.

16.4 Winged-helix (Forked head) proteins.

16.5 Leucine-Zipper proteins.

16.6 Helix Loophelix proteins.

17. Protein sorting: Organelle biogenesis and protein synthesis.

17.1 Synthesis and targeting of mitochondrial and choloroplast proteins.

17.2 Synthesis and targeting of peroxisomal proteins.

17.3 Secretory pathways.

17.4 Translocation of secretory proteins across the ER membrane.

17.5 Insertion of membrane proteins in the ER membrane.

17.6 Post-translation modifications in rER.

17.7 Protein glycosylation in ER and Golgi complex.

17.8 Golgi and Post-Golgi protein sorting and proteolytic processing.

17.9 Receptor-mediated endocytosis and sorting of internalized proteins.

17.10 Molecular mechanisms of vesicular traffic.

CELL & MOLECULAR BIOLOGY
PAPER-VI

3 Hours Duration ***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 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.

1. Molecular Immunology

1.1 Discovery of humoral and cellular immunity.

1.2 Early theory of immunity.

1.3 Components of immunity.

1.4 Innate (nonspecific) immunity.

1.4.1 Anatomic barrier.

1.4.2 Physiologic barriers.

1.4.3 Phagocytic barriers.

1.4.4 Inflammatory barriers.
1.4.5 Collaboration between innate and adaptive immunity.
1.5 Adaptive (specific) immunity.
1.5.1 Cell of the immune system (B-lymphocytes, T-lymphocytes and Antigen presenting cells).
1.5.2 Functions of humoral and cell-mediated immune responses.
1.5.3 Recognition of antigen by B-and T-lymphocytes.
1.5.4 Generation of lymphocyte specificity and diversities.
1.5.5 Role of MHC
1.5.6 Processing and presentation of antigen.
1.5.7 Clonal selection of lymphocytes.
1.5.8 Cellular interactions required for generation of immune responses:
a. Activation and proliferation of T-Helper cells
b. Generation of Humoral immune response
c. Generation of CMI

2. Cells and organs of immune system
2.1 Hematopoeisis
2.1.1 B-Lymphocytes, T-lymphocytes, Null, cells.
2.1.2 Mononuclear cells phagocytes (antimicrobial and cytotoxic activities: antigen processing and presentation, secretion of factors).
2.1.3 Granulocytic cells (Neutrophils, Eosinophils and Basophils).
2.1.4 Mast cells.
2.1.5 Dendritic cells.
2.2 Organs of immune system.
2.2.1 Primary lymphoid organs (Thymus, hone marrow).
2.2.2 Lymphatic system.
2.2.3 Secondary lymphoid organs (Lymph nodes, spleen, mucosal associated lymphoid tissue, cutaneous associated lymphoid tissue).

3. Antigens
3.1 Immunogenicity versus antigenicity.
3.2 Factors that influence immunogenicity.
3.2.1 Contribution of the immunogens (foreignness, mo-

lecular size, chemical composition and heterogenesity, susceptibility to antigen processing and presentation).

3.2.2 Contribution of Biological system. (Genotype of the recipient animal, immunogen dosage and route of administration, adjuvant).

3.2.3 Heptans.

4. Immunoglobulins: Structure and function

4.1 Molecular structure of Ig, Light chain and Heavy chain

4.2 Immunoglobulin domains.

4.2.1 Variable region domains (CDRs and antigen binding, conformational changes included by antigen bindi binding).

4.2.2 Constant region (CH and CL domains, hinge region and other constant region domains).

4.3 Immunoglobulin classes (lgG.lgM, IgA, IgE and lgD and their biological activities.

4.4 Immunoglobulin-mediated effectors functions (Opsonization activation of complement, antibody dependent cell mediated cytotoxicity).

4.5 Antigenetic determinants on immunoglobulin (isotype, allotype and idiotype).

4.6 Monoclonal antibodies.

4.6.1 Formation and selection of hybrid cells.

4.6.2 Production of monoclonal antibodies.

4.6.3 Clinical uses of monoclonal antibodies.

4.6.4 Catalytic monoclonal antibodies (enzymes).

5. Organization and expression of Ig genes

5.1 Genetic model compatible with Ig structure.

5.1.1 Germ line and somatic variation models.

5.1.2 Two gene model of Dryer and Bennett.

5.1.3 Verification of Dryer and Bennett hypothesis.

5.2 Multigene organization of Ig genes.

5.2.1 I-chain multigene family

5.2.2 K-chain multigene family.

5.2.3 Heavy chain multigene family.

5.3 Variable region gene rearrangement.

5.3.1 V-J rearrangements in light chain DNA.

5.3.2 V-D-J rearrangements in heavy chain DNA.

5.4 Mechanism of variable region DNA rearrangement.
- 5.4.1 Recombination signal sequences.
- 5.4.2 Enzymatic joining of gene segments.
- 5.4.3 Identification of Raf-1 and Raf-2 genes.
- 5.4.4 Defects in Ig gene rearrangements.
- 5.4.5 Productive and nonproductive rearrangement.
- 5.4.6 Allelic exclusions.

5.5 Generation and antibody diversity.
- 5.5.1 Multiple germ line V.D and J gene segments.
- 5.5.2 Combinatorial V-J and V-D-J joining.
- 5.5.3 Junctional Flexiblity.
- 5.5.4 P-addition and N-addition.
- 5.5.5 Association of heavy and light chain.

5.6 Class switching among constant region genes.
- 5.6.1 Expression of Ig genes
  - a. Differential RNA processing of heavy chain primary transcripts.
  - b. Expression of membrane of secreted Ig.
  - c. Stimultaneous, assembly and secretion of IgM and IgD.
  - d. Synthesis, assembly and secretion of Ig~
- 5.6.2 Regulation of Ig gene transcription.
  - a. Effect of DNA rearrangement of transcription.
  - b. Inhibition of Ig-gene expression in T-cells.
- 5.6.3 Antibody genes and antibody engineering.
  - a. Chimeric and hybrid monoclonal antibodies.
  - b. Monoclonal antibodies constituted from Ig gene libraries.

6. Antigen - Antibody Interaction

6.1 Antibody affinity and avidity.
6.2 Cross reactivity.
6.3 Agglutination reactions.
6.4 Precipitation reaction.
6.5 Complements and complement fixation test.

7. Major histocomptability complex.

7.1 General organization and inhertance of MHC.
- 7.1.1 Location and function of MHC regions.
- 7.1.2 MHC haplotypes.

7.1.3 Congenic MHC mouse strains.

7.2 MHC molecules and genes.

7.2.1 Structure of class I molecules.

7.2.2 Structure of class II molecules.

7.2.3 Organization of class I and Li genes.

7.2.4 Peptide binding by MHC molecules.

7.2.5 Class III molecules.

7.3 Genomic maps, of MHC genes.

7.3.1 Maps of class I MHC.

7.3.2 Maps of class II MHC.

7.3.3 Maps of class III MHC.

7.4 Cellular distribution of MHC molecules.

7.5 Regulation of MHC expression.

7.6 MHC and immune responsiveness.

7.7 MHC and diseases susceptibility.

8. Antigen Processing and Presentation

8.1 Role of antigen presenting cell.

8.1.1 Early evidence for the necessity of antigen processing.

8.1.2 Cells that function in antigen presentation.

8.2 Evidence for two processing and presentation pathways.

8.2.1 Endogenous antigens. The cytosolic pathways.

a. Peptide generation by proteosomes.

b. Peptide transport from the cytosol to RER.

c. Assembly of peptide with class I MHC molecules.

8.2.2 Exogenous antigens: The endocytic pathway.

a. Peptide generation in endocytic vesicles.

b. Transport of class II MHC molecules to endocytic vesicles.

c. Assembly of peptide with class 11 MHC molecules.

8.3 Presentation of nonpeptide bacterial antigenes.

9. Cytokines

9.1 Properties of cytokines.

9.2 General structure of cytokines.

9.3 Function of cytokines.

9.4 Cytokines related diseases.

9.4.1 Bacterial septic shock.
9.4.2 Bacterial toxic shock and similar diseases.
9.4.3 Lymphoid and myeloid cancers.
9.4.4 Chagas diseases.

10. Immune system in health and diseases

10.1 Immune response to infectious diseases.
10.1.1 Viral infections.
a. Viral neutralization by humoral antibody.
b. Cell mediated antiviral mechanism.
c. Viral evasion of host defence mechanisms.
10.1.2 Bacterial infections.
a. Immune responses to extra-cellular and intracellular bacteria.
b. Bacterial evasion of host defense mechanism.
10.1.3 Protozoa and diseases.
10.1.4 Diseases caused by helminthes.

11. Vaccine

11.1 Active and passive immunization.
11.2 Designing vaccines for active immunization..
11.3 Whole organism vaccine.
11.3.1 Attenuated viral or bacterial vaccines.
11.3.2 Inactivated viral or bacterial vaccines.
11.4 Polysaccharide vaccines.
11.5 Recombinant vector vaccines.
11.6 DNA vaccines.
11.7 Synthetic peptide vaccines.
11.8 Multivalent peptide vaccines.

12. AIDS and other immunodeficiencies

13. Autoimmunity

13.1 Organ specific autoimmune diseases.
13.2 Systemic autoimmune diseases.
13.3 Proposed mechanisms for induction of autoimmunity.

14. Cancer and immune system

15. Transplantation immunology

16. Cellular Energetics

16.1 Electron Transport and Oxidative Phosphorylation.
16.1.1 Proton Motive Force.
16.1.2 Electron flow.

16.1.3 Shutting of electrons between ETC.
16.1.4 Reduction potentials of electron carriers.
16.1.5 Pumping protons out of the mitochondrial matrix.
16.1.6 ATP syntheses.
a. FoF1 complex and proton motive force.
b. Inner mitochondrial membrane transporters and proton motive force.
c. Regulation of mitochondrial oxidation rate.
16.1.7 Chemiosmotic mechanism of ATP formation and related experiments.
16.2 Photosynthesis.
16.2.1 Photosynthesis and thylokoid membrane.
16.2.2 Stages of Photosynthesis.
16.2.3 Light absorption and charge seperation across thylokoid membrane.
16.2.4 Molecular analysis of photosynthesis.
16.2.5 CO_2 metabolism during photosynthesis.

CELL & MOLECULAR BIOLOGY
LIST OF PRACTICALS

1. **Operation of various microscopes**
   1.1 Use of phase contrast.
   1.2 Use of fluoresecene microscope and demonstration of nucleic acid by acridin orange or thidium bromide.
   1.3 Use of transmission electron microscope.
   1.4 Use of occulometer-Standardization and measurements of cell height, nuclear diameters and tabular diameters.
   1.5 Use of occular grid- standardization and counting of cells or nuclei in cross section or epithelium.
2. **Preparation of biological tissues and sectioning for**
   2.1 Paraftin wax histology by microtome.
   2.2 Fresh- frozen by cryostat.
   2.3 Ultrathin sectioning by ultratome.
3. **Cytochemistry**
   3.1 Carbohydrate (a) PAS method (b) Alcian blue method.
   3.2 Proteins (a) Mercury bromophenol blue method (b) Ninhydrin method.
   3.3 Lipids (a) Phosphomolybic acid method (b) Copper phthalocynin method.

3.4 Nucleic acid (a) Feulgen method (b) Methyl green- Pyronin method.

4. Biochemical methods

4.1 Determination of pK value of buffer.

4.2 Determination of absorption maximum of a solution.

4.3 Determination of relationship between absorption and various concentration of a solution using a colorimeter, spectrocolorimeter/spectrophotometer.

4.4 Preparation of standard curve for proteins, lipids, carbohydrates and enzymes.

4.5 Determination of optimum concentration of enzyme for kinetic studies.

4.6 Determination of Michaelis - Menten (KM) and Vmax for an enzyme by Thumer's method.

4.7 Quantitation of enzymes.

4.7.1 by end point techniques as examplified by alkaline and acid phosphatase.

4.7.2 by substrate - left over technique as examplified by LDH.

4.7.3 by turn over number as examplified by GST

5. Fractination

5.1 Tissue homogenization and fractionation by differential centrifugation for isolation of mitochondria, nuclei and cystol and use of marker enzymes for assessment of purity of the components.

5.2 Fractionation of protein, RNA and DNA and their Quantification.

6. Separation techniques

6.1 Separation of proteins and DNA by agarose electrophoresis.

6.2 Separation of proteins and isoenzymes on SDS-PAGE and PAGE.

6.3 Electroeluting of proteins DNA/RNA from electrophoretic gels.

6.4 Separation of amino acids by paper chromatography.

6.5 Separation of phospholipids by TLC.

6.6 Separation of haemoglobin by column chromatography.

7. Chromosomal techniques

7.1 Preparation of salivary gland chromosomes from Drosophila,

Chironomous larva and stain with acetocarmine/acetoorcin/ feulgen.

7.2 Preparation of mammalian chromosomes from bone marrow or testis and stain with Giemsa stain.

8. Immunization techniques

8.1 Emulsification with Freund's reagent.

8.1.1 Preparation of emulsions with syringe method.

8.1.2 Preparation of emulsion with double hubbed needle method.

8.2 Testing type of emulsion.

8.3 Absorption of soluble proteins on insoluble colloidal carrier.

8.3.1 Alum precipitates.

8.3.2 Alum hydroxide adjuvants.

9. Immunization route

9.1 Intradermal.

9.2 Subcutaneous.

9.3 Intramuscular.

9.4 Intraperitioneal.

9.5 Intravenous.

9.6 Foot pad.

10. Bleeding schedules and collection of blood

10.1 Bleeding from ear.

10.2 Retro-orbital.

10.3 Cardiac puncture.

10.4 Branchial vein.

10.5 From external jugular vein.

11. Sepration and preservation of serum

11.1 Liquid storage.

11.1.1 Using preservative.

11.1.2 Sterilization.

11.2 By freezing.

11.3 By lyophilization.

12. Isolation of T and B cells from sensitized animals

12.1 From spleen.

12.2 From lymph nodes.

12.3 From human blood-rosette formation with sheep RBC.

13. Purification of antibodies and antigens

13.1 Insolubilization of antibodies an antigenic proteins using gluteraldehydes.

13.2 Immunoadsorption.

13.3 Dissociation of absorbed material from immunoadsorbents.

14. **Quantitation of antibodies**

14.1 Percipitation techniques.

14.2 Immunodiffusion method.

14.3 Immunoelectrophoresis method.

15. **Immunoassays: RIA, ELISA**

16. **Permanent slides (for spotting)** : Thymus, lymph nodes, spleen, bone marrow, types of cells (squamous, cuboidal, columnar epitheial cells, blood cells, nerve cells, muscle cells, connective tissues of various types, adipose tissues, mitotic & meiotic chromosomes and their different phases cancer cells of various types etc.)

SCHEME OF PRACTICAL EXAMINATION

Duration: 5 Hrs. **Max. Marks: 100**

1.	Exercise on Microtomy/ Crysotat/ Ultramicrotome Sectioning	10
2.	Exercise on Cytochemistry.	10
3.	Exercise on biochemical estimation.	10
4.	Ecercise on Differential centrifugation/ chromatography/ electrophoresis.	10
5.	Exercise on immunology.	10
6.	Exercise on chromosomal preparation.	10
7.	Identification and comment (Spots-five, 4 marks each).	20
8.	Viva - voce	10
9.	Record	10
		Total = 100

CELL & MOLECULAR BIOLOGY:

Suggested Reading Materials :

1. Micklos D.A. and Freyer G. A. DNA science A first course in recombinant DNA Technology. Carolina Biological supply compo and Cold Spring Harbour Laboratoy Press, Burlington , North corolina, 1990.
2. Lucent Micklos D.A. and Freyer G. A. DNA science A first course in recombinantDNA Techanology. Carolina Biological supply compo and Cold Spring Harbour Laboratoy Press, Burlington, North Corolina, 1990B. Genes VII. Oxford University Press, Oxford, 2000.

3. Old R. W. and Primrose S. B. Principles of Gene Manipulation. An introduction to genetic engineering. Blackwell Scientific Publication. London, 1989.
4. Twyman R. M. and Wisden W. Advanced Molecular Biology, A Concise Reference Viva Books Pvt. Ltd. New Delhi: 1999.
5. Gasque, C. E. A. Manual of laboratory experiences in Cell Biology Universal Book Stall, New Delhi.
6. Meyers R.A. Molecular Biology and Biotechnology, A comprehensive desk Reference. VCH Publishers, Inc., New York, 1995.
7. Lodish H, Berk A, Zipursky S. L., Matsudaira P, Baltimore D. and Darnell 3. Molecular Cell Biology W.H. freeman and Company, New York, 2000.
8. De Robertis E.D.P. and De Robertis Jr, E.M.F., Cell and Molecular Biology. K. M. Varghese Cop. Bombay, 1998.
9. Adams RLP. Knowler J.T. and Leader D.P. The Biochemistry of the Nucleic Acids. Chapman and Hall, London, 1986.
10. Walker J.M. and Gingold E.B. Molecular Biology and Biotechnology Purnima Educational Book Agency, New Delhi, 1992.
11. Alkberts B, Bray D, Lewis, J, Raff, M, Roberts, K and Watson J.D. Molecular Biology of the Cell. Garland Publishing, Inc. New York, 1994.
12. Glick B. R. and Pasternak 1.1. Molecular Biotechnology Principles and Applications of Recombinant DNA. ASM Press, Washington, 1998.
13. Bolrover S.R. Hyams J.S., Jones S. Shephard E.A. and White H.A. From genes to cells. Wiley-liss, New York, 1997.
14. Winnacker E.L. From genes to clones Introduction to gene technology, Purnima Education Book Agency, New Delhi. VCH Publishers, New York, 1987.
15. Gerbare J. and Kirschner M. Cells, Embryos and Evolution. Blackwell science, Inc. Massachusetts, 1997.
16. Giese A. C. Cell Physiology, WB. Saunders Co., Philadelphia, 1979.
17. Freifelder D. Molecular Biology, Narosa Publishing House, New Delhi, 1997.
18. Frieerg E.C., Walker G.C. and Siede, W. DNA Repair and Mutagenesis. ASM Press Wadbington DC, 1995.

19. Karp G. Cell and Molecular Bio-logy. Concepts and experiments. John Wiley and Sons. Inc. New York, 1999
20. Malacinski G.M. and Freifelder D. Essentials of Molecular Biology Jones and Bartlett Publishers Boston, 1999
21. Cooper, G.M. The cell A molecular approach. ASM Press, Washington DC, 2000.
22. Shelve P. and Blanch DEW, Cell and Molecular Biology. John Wiley and Sons Inc., New York, 1994.
23. Darnell, J.L. Lodish, H. and Baltimore, D. Molecular Cell Biology, Scientific American Books Inc. New York.
24. Watson, J.D., Hopkins, N.H. Roberts, J.W Steitz, J.A. and Weiner A.M. Molecular Biology of the Gene. The Benjamin/Cumings Pub. Co. Inc. California
25. Gardner, EJ. Simons, MJ. and Snustad, D.P. Principles of Genetics. John Wiley & Sons Inc. New York
26. Voet, D. and Voet, J.G. Biochemistry, John Wiley & Sons Inc New York.
27. Zubay, G.L. Parson, W.W. and Vance, D.E. Principles of Biochemistry. Wm.C. Brown Publishers, Oxford, England.
28. Goldsby, RA. Kindt, T.J. and Osborne, B.A. Kuby Immunology, W.H. Free- I man & Co. New York.
29. Abbas. A.K. Lichtman, AR. and Pahes, J.S. Molecular Immunology, W.B. Saunders & Co., London
30. Cruse. J.M. and Lewis, RE. Atlas of Immunology, CRC Press,New York.
31. Talwar, G.P. and Gupta. S.K A Handbook of Practical and Clinical Immunology. Vol.I & II. Vikas Publishing House Pvt. Ltd., New Delhi.
32. Dabre, D.D. Introduction to Practical Molecular Biology, John Wiley & Sons Inc; New York.

3. DEVELOPMENTAL BIOLOGY

PAPER-V: CONCEPTS OF EMBRYOLOGY

Duration : 3 Hrs. **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 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.

1. History/Discoveries.
   1.1 Theories of development.
   1.2 Fundamental Problems of Developmental Biology.
   1.3 Scope and application of Developmental Biology.
2. Patterns of reproduction.
   2.1 Asexual; Sexual; reproductive habits and breeding cycles in Vertebrates.
   2.2 Types of reproductive cycles in mammals.
3. Ovulation and its control.
   3.1 Induced breeding in fish and frog.
4. Gogenesis:
   4.1 Differentiation and growth of oocytes.
   4.2 Organization of egg.
   4.3 Cytoplasm and egg cortex.
   4.4 Origin of polarity and symmetry in eggs.
   4.5 Vitellogenesis.
5. Spermatogenesis:
   5.1 Differentiation.
   5.2 Ultrastructure; biochemistry and types of sperms.
   5.3 Capacitation.
6. Fertilization.
   6.1 Biological role of fertilization.
   6.2 Basic requirements of fertilization.
   6.3 Recognition between male and female gametes.
   6.4 Acrosome reaction of sperm.
   6.5 Cortical reaction of egg.
   6.6 Sperm penetration into egg.
   6.7 Prevention of polyspermy.
   6.8 Activation of egg metabolism.
   6.9 Biochemistry of fertilization.
   6.10 Biology and viability of sperms and ova.

6.11 Activation of gamete metabolism-early and late responses.
6.12 Parthenogenesis.
6.13 Artificial insemination.
6.14 Fusion of genetic material in mammals.
6.15 Fertilization in vitro.
6.16 Cultivation and re implantation and significance of this technique.
6.17 Control of human fertility.
6.18 Birth control.
6.19 Contraception.
6.19.1 Natural.
6.19.2 Barrier or mechanical contraceptives.
6.19.3 Method of contraception in human beings.
6.20 Artificial insemination in cattle.
6.21 Test tube baby, its advantages and disadvantages.
6.22 Cryopreservation of human embryos.
6.23 Gamete intra-fallopion transfer (GIFT).

7. Cleavage:
7.1 Role of nucleus.
7.2 Problem of DNA synthesis; energy requirements; biochemical changes; distribution of morphogenetic substances of egg and their role during cleavages
7.3 Characteristics and mechanism of cleavages.

8. Early embryonic development in selected non-chordates and chordates (with particular reference to the type of eggs; pattern of cleavages; blastulation; gastrulation; establishment of three germ layers and the basic body plan).
8.1.1 Coelenterate.
8.1.2 Ctenophora.
8.1.3 Platyhelmenthes.
8.1.4 Annelida.
8.1.5 Mollusca.
8.1.6 Echinodermata.
8.1.7 Insecta.
8.2 Chordates (frog, chick and mammals).
8.3 Determination of embryonic axes and cell lineage in mammalian development.

9. Morphogenetic cell movements.

9.1 Dissociation and reaggregation of cells.
9.2 Selective affinities of cells during development.

10. Fate maps.
    10.1 Methods of their constructions, utility; comparative topographical relationship of the resumptive areas in early embryos of
        10.1.1 Amphioxus.
        10.1.2 Fishes.
        10.1.3 Amphibian.
        10.1.4 Birds.
11. Neurulation in Vertebrates.
    11.1 Mechanism of neural tubes formation.
    11.2 Segregation of mesodermal and endodermal organ rudiments.
12. Determination :
    12.1 Concepts of prospective fates, potencies; progressive determination and differentiation mosaic and regulative eggs-a problem of determination.
13. Restriction of potencies in the germinal layers of amphibians and birds; cytoplasmic determination of germ cells in nematodes, drosophila and frog.
14. Cell and tissue interactions in development.
    14.1 Primary embryonic induction.
    14.2 Nature and regional specificity of induction.
    14.3 Methods of study and analysis of the phenomenon of neural induction.
    14.4 Heterogeneous inductors.
    14.5 Chemistry and properties of inducing substances.
    14.6 Competence.
    14.7 Mechanism and theories of induction.
    14.8 Secondary and tertiary inductors.
        14.8.1 Concept of organizer.
        14.8.2 Evocation and Individuation.
        14.8.3 Trans determination in insect germinal discs.
        14.8.4 Ectodermal and mesodermal interactions in the morphogenesis of limbs in vertebrates.
        14.8.5 The role of apical ridge.
15. Inductive interactions in the morphogenesis and differentiation of the eye in vertebrates.

16. Origin and development of nerve cells and nerve fibres, computer analysis of cellular interactions.
17. Gradients:
    17.1 The concepts; child's hypothesis.
    17.2 Metabolic differences in embryonic cell.
    17.3 Biochemical gradients in sea-urchin eggs and their morphogenetic importance.
18. Morphogenetic fields.
    18.1 The concepts; nature and temporal character of fields.
    18.2 Progressive determination within a field.
19. Segmentation of vertebrate embryo.
20. Development of ectodermal organs.
    20.1 Brain.
    20.2 Neural crest and its derivatives.
    20.3 Skin.
    20.4 Scale and feather.
21. Development of mesodermal organs.
    21.1 Heart.
    21.2 Kidney.
    21.3 Gonads.
    21.4 Reproductive duets.
22. Development of endodermal organs.
    22.1 Liver.
    22.2 Pancreas.
    22.3 Thymus.
23. Differentiation :
    23.1 Definition and biochemical basis of differentiation.
    23.2 Structural and biochemical changes during differentiation of.
        23.2.1 Muscle.
        23.2.2 Cartilage.
        23.2.3 Pigment cells.
        23.2.4 Lens
        23.2.5 Fibres.
        23.2.6 Mammalian erythroid cells
        23.2.7 Epidermis.
    23.3 Concept of stem cells and establishment of tissue specific cell lines.

23.4 Cell division and cytodifferentiation.
23.5 Stability of differentiated state of cells.
23.6 Chemical control of differentiation.
23.7 Influence of animalizing and vegetalizing agents on sea urchin.
23.8 De-differentiation; modulation and metaplasia.
23.9 Trans- differentiation, influence of hormones on differentiation of tissues and organs.

24. Development of the immune system.
25. Cell, tissue and organ culture.
25.1 Basic requirements.
25.2 Design of the laboratory.
25.3 Balanced salt solution.
25.4 Use of antibiotics.
25.5 Culture media.
25.6 Methods of preparation of cell, tissue and organ for cultivation in vitro.
25.7 Contribution of culture studies in developmental biology.

3. DEVELOPMENTAL BIOLOGY

PAPER-VI: GENES AND DEVELOPMENT

Duration : 3 Hrs. **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 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

1. Role of cell surface in morphogenesis.
2. 2.1 Pattern formation.
2.1.1 General and theoretical aspects of pattern formation.
2.1.2 Polarity.
2.1.3 Apical dominance.
2.1.4 Positional information.

2.1.5 Pattern formation in limb development in vertebrates.
2.1.6 Feather pattern in birds and wing pattern in insects.
2.1.7 Importance of retinoic acid in pattern formation in amphibia and birds.

3. 3.1 Nuclear transplantation in amphibians and mammals.
3.2 Cloning.
3.3 Pleuripotency of somatic cells.
4. Role of nucleus and cytoplasm in development.
4.1 Molecular exchange between cytoplasm and nucleus.
4.2 Nuclear control of morphogenesis.
4.3 Nuclear transplantation between species.
4.4 Prevention of chromosomal diminution in the germ cells of Ascaris by cytoplasmic determinants.
5. Genetic interaction in cell differentiation.
6. Genetic control of development.
6.1 At transcriptional level.
6.2 At translational level.
6.3 Post-translational control.
6.4 Epigenetic modification of proteins.
6.5 Determination of embryonic axis.
6.6 Segmentation of larval body.
6.7 Homeotic genes.
7. Function of genes during development transgenic cells and organisms.
8. Gene interactions in development: Gene action; Homeobox.
9. Differential gene function during development.
9.1 Changing patterns of tissue specificity of protein synthesis.
9.2 Embryonic, fetal and adult hemoglobin's.
9.3 Differential RNA synthesis.
10. Gene mutations affecting programmed cell death.
11. Homeotic mutations.
11.1 Bombyx mori.
11.2 Bithorax locus in Drosophila.
11.3 Anteprnapedia locus in Drosophila.
11.4 Relationship of developmental biology with genetics and evolution.
11 5 Ontogeny and phylogeny.
11.6 Morphological recapitulation of phylogeny in ontogeny.

11.7 Molecular recapitulation in ontogeny.
11.8 Urea cycle in vertebrate phylogeny and ontogeny.
11.9 Arboreal salamanders and frogs without tadpoles-heterochrony and morphological adaptation.
11.10Diversity of modes of reproduction in frogs of temperate and tropical regions.
11.11Mechanism of amphibian hetro-chrony.

12. Ectodermal mesodermal interactions in the morphogenesis of limb in vertebrate.
    12.1 The role of apical ridge.
    12.2 Specification of the anterior-posterior limb axis.
    12.3 Hox genes.
    12.4 Polarizing zones.
13. Route of cell death in morphogenesis.
    13.1 Development of the terapod limb.
    13.2 Cell death in formation of digits and joints.
14. Growth:
    14.1 Dynamics of population growth.
    14.2 Isometric and allometric.
    14.3 Differential growth.
    14.4 Physiological mechanism of growth.
15. Ageing (Senescence).
    15.1 Cellular basis of ageing.
    15.2 Maximum life span and life expectancy.
    15.3 Oxidative damage.
    15.4 Mitochondrial genome damage.
    15.5 Genetic basis of ageing.
    15.6 Telomere shortening.
    15.7 Theories of ageing.
    15.8 Ageing of cells in vitro.
16. Environmental regulation of animal development.
    16.1 Abnormal growth (Teratomas).
    16.2 Teratology-types of abnormalities.
    16.3 Genetic effects (pleiotropism, phenocopies, canalization, and inborn errors in metabolism).
    16.4 Environmental effects.
    16.5 Teratogenic agents (drugs, nutritional deficiencies, injections, ionizing radiation).

16.6 Retinoic acid as a teratogen.
16.7 Alcohol as a teratogen.
16.8 General mechanisms and mode of action of teratogenic agents.
17. Embryological considerations in teratology.
18. Twinning.
19. Malignancy:
19.1 General characteristics and properties of cancer cells including structural and metabolic alterations in these cells.
19.2 Metaplasia and carcinogenic agents.
20. Embryonic adaptations:
20.1 Cleidoic eggs.
20.2 Development, structure and physiology of extra-embryonic membranes in amniotes.
20.3 Development, structure and physiology of placenta in Eutherian mammals.
21. Embryonic nutrition.
21.1 Yolk utilization by embryos of invertebrates and vertebrates.
21.2 Fetal nutrition in mammals.
21.3 Placental physiology.
22. Metamorphosis:
22.1 Larval forms of non-chordates and chordates and their morphological transformation to adult form.
22.2 Morphogenetic changes during metamorphosis in insects and their hormonal control.
22.3 Morphological, biochemical and physiological changes during metamorphosis in amphibians and their hormonal control.
23. Regeneration:
23.1 Definition; characteristic of regeneration and its comparison with ontogenetic development.
23.2 Distribution of regenerative ability in animal kingdom.
23.3 Forms and patterns of regeneration.
23.4 Morphollaxis.
23.5 Epimorphosis.
23.6 Regeneration in Hydra.
23.7 Regeneration in Planaria.

23.8 Appendage regeneration in arthropods and its relation with molting and metamorphosis.
23.9 Heteromorphosis.
23.10 Autotomy.
23.11 Regeneration in vertebrates with special reference to morphological and histological study of this phenomenon on.
23.11.1 Tail regeneration.
23.11.2 Limb regeneration.
23.11.3 Wolffian lens regeneration.
23.12 Sources of cells for regeneration.
23.13 Dedifferentiation.
23.14 Wound healing.
23.15 Role of wound epidermis and the epidermal cap.
23.16 Blastula morphogenesis.
23.17 Distal transformation.
23.18 Role of nerves and hormones.
23.19 Pattern formation in blastula by retinoic acid-proximalization.
23.20 Homeotic transformation of tails into limbs.
23.21 Loss of regenerative ability in anuran larvae and adults and experimental attempts to restore it.

24. Liver regeneration in mammals.
25. Methods of preparation and utility of normal tables of embryonic and larval developmental stages.

PRACTICALS: DEVELOPMENTAL BIOLOGY

1. Detailed study of early embryonic development of a fish, an amphibian, chick and a mammal through preserved materials; whole mounts and serial sections.
2. Study of morphogenesis and histogenesis of some selected organs such as limb, heart, eye, brain, etc. during embryonic and/or larval development of vertebrates through preserved materials, whole mounts and sections.
3. Study of morphological and histological developments during tail and limb regeneration in any amphibian.

4. Study of metamorphosis and its endocrine control in an insect and an amphibian.
5. Hypophysectomy in a living frog or toad.
6. Microscopic study of sperms and ova of frog after appropriate staining.
7. Simple experiments on frog or toad embryos such as cultivation of parts of embryos in vitro, parabiosis transplantation, implantation, etc.
8. Microtomy of vertebrate embryos and larvae.
9. Alizarine and victoria blue preparation of a late chick embryo, mammalian foetus/a frog or toad tadpole.
10. Study of oestrous cycles in a rodent.
11. Simple experiments on chick embryos such as cultivation of early embryos in vitro by ring technique, intrablastodermic and chorio-allantoic grafting, demonstration of morphogenetic movement and metabolic gradients, study of cell-death in limbs of chick embryos, influence of teratogenic agents(s) on embryonic development, etc.
12. Simple exercise on preparation of glass instruments; fine agar film stained with vital dyes; culture media such as embryo extract, Plasma clot, etc.
13. Identification and separation of free amino-acids in embryonic and larval tissues and organs by paper chromatography.
14. Simple exercises on in vitro cultivation of embryonic tissues and organs by suitable techniques.

Scheme of Practical Exam.

4. ENDOCRINOLOGY

PAPER-V: ENDOCRINE GLANDS

Duration : 3 Hrs. **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 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

1. **Historical background**, scope and status of endocrinology. 2
2. **Endocrine glands**: an overview. 1
3. **Biochemical nature of hormones.** 2
4. **Mechanism of action of hormones.** 4
5. **Study of the following major endocrine glands of vertebrates:**
   (a) **Pituitary:** General, developmental and comparative anatomy; functional cytology of the pituitary gland of mammalian and sub-mammalian vertebrates; adenohypophyseal hormones, their chemistry and physiology, chromatophore regulation among vertebrates; neurohormonal peptides; their chemistry and phyletic distribution; formation, storage, release and transport of neurohypophyseal principles; effects of hypophysectomy. 8
   (b) **Thyroid:** General, developmental and comparative anatomy; evolution of thyroidal function, biochemistry, biological actions of thyroid hormones and their inter-relationship with other endocrine secretions; effects of thyroidectomy; calcitonin: its chemistry and physiology. 5
   (c) **Parathyroid:** General, developmental and comparative anatomy; biochemistry and physiology of the parathyroid hormone; effects of parathyroidectomy. 5
   (d) **Pancreatic Islets:** General, developmental and comparative anatomy; biochemistry and physiology of insulin and glucagon; effects of pancreactomy. 4
   (e) **Adrenal :** General, developmental and comparative anatomy; chromaffin tissue, biochemistry and physiology of catecholamines; the sympathetico-chromaffin complex; steroidogenic tissue : structure and nomenclature of steroid hormones; biochemistry and physiology of adrenal steroids; effects of adrenalectomy. 8
   (f) **Pineal :** General, developmental and comparative anatomy; biochemistry and physiology of the pineal principles. 4
6. **The female reproductive system :** Comparative anatomy and physiology of the mammalian and sub-mammalian ovary and sex accessory structures, ovarian hormones and their functions. 10

7. **The male reproductive system** : Comparative anatomy and physiology of the mammalian and sub-mammalian testis and secondary sex accessory structures, testicular hormones and their functions, semen and its biochemistry. 10
8. **The hypothalama-hypophyseal-gonadal relationship.** 3
9. **Biology of spermatozoa and ovum** : Structure, development and function. 4
10. **Endocrinology of fertilization,** implantation, delayed implantation, parturition and lactation. 6
11. **Placenta as an endocrine tissue;** foeto-placental unit. 4
12. **Hormonal control of sex differentiation and sex determination** 4
13. **Assisted reproductive technology (ART).** 5

4. ENDOCRINOLOGY

PAPER-VI: REGULATORY ASPECTS

Duration : 3 Hrs. **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 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.

1. **Vertebrate neuroendocrinology** : Ultrastructure and function of the neuro-secretory cell, hypothalamo-hypopyseal relationship, hypothalamus in relation to higher nervous centres, other neurosecretory systems in vertebrates, the urophysis, the subcommissural organ and the pineal complex. 10
2. **Invertebrate neuroendocrinology**: Anatomy and physiology of the endocrine and neuro-endocrine systems of Annelida, Arthropoda and Mollusca. 10
3. **Endocrine integration**: Diffuse effects of hormones: neoplastic growth; migration in birds and fishes; bird plumage; hibernation; osmoregulation; blood pressure regulation. 10

4. **Breeding seasons in vertebrates**, evolution of viviparity, induced spawning in fish and frog. 6
5. **Hormones and reproductive behaviour**. 3
6. **Functional aspects of chemical**, mechanical and surgical and immunological control of male fertility in laboratory mammals and the human. 12
7. Functional aspects of chemical, mechanical, surgical and immunological control of female fertility in laboratory mammals and the human. 12
8. **Pheromones** : Control of fertility in insects. 3
9. **Prostaglandins** : Types, chemistry, mechanism of action and their effects on mammalian reproduction. 6
10. **Hormonal imbalance and major endocrine diseases** : 20
    (a) Gigantism.
    (b) Acromegaly.
    (c) Dwarfism.
    (d) Addison's disease.
    (e) Cushing's syndrome.
    (f) Goitre.
    (g) Cryptorchidism.
    (h) Hypogonadism.
    (i) Amenorrhoea.
    (j) Diabetes mellitus.
    (k) Tetany.

List of Practicals:

1. Dissection and gross examination of various endocrine glands of representative vertebrates.
2. Microscopical study of various endocrine glands of representative vertebrates through microtechnical procedure.
3. Study of the estrous cycle in mouse or rat by the vaginal smear technique.
4. Surgical procedures: castration, ovariectomy, adrenalectomy, thyroidectomy and hypophysectomy.
5. Bioassays for estrogens, androgens and antiestrogens; the Ascheim Zondek pregnancy test.
6. Biochemical estimations of cholesterol and ascorbic acid content in adrenal tissue; glycogen content in uterine tissue; fructose content in male sex accessory glands.

7. Sperm count and motility.
8. Study of the sex chromatin.
9. Effects of epinephrine on chromatophores in fish.
10. Study of microscopic slides of endocrine and related structures.

SCHEME OF PRACTICAL EXAMINATION AND DISTRIBUTION OF MARKS:

Duration : 5 Hrs. **Max. Marks :100**

1. Dissection or surgical procedure.	12
2. Exercise on bioassay or hormone administration effects.	10
3. Quantitative estimation of glycogen/cholesterol/ascorbic acid/ fructose in a given endocrine tissue.	12
4. Exercise on sperm count/vaginal cycle/effect of epinephrine on fish chromatophres.	8
5. Microtomy.	14
6. Identification and comments on the spots (1 to 8)	24
7. Viva-voce.	10
8. Class record.	10
Total	**100**

ENDOCRINOLOGY BOOKS RECOMMENDED:

1. Gorbman, A. and Bern, H.A. A Text Book of Comparative Endocrinology, John Wiley and Sons Inc., New York, 1962 (Indian Edition- Wilei Eastern Pvt. Ltd., New Delhi, 1974.)
2. Turner, C.D.: General Endocrinology'*ftW*, 13: Saunders and Co. Philadelphia, 1974. Toppan Co. Pvt. Ltd., Singapore, 1974.
3. Nalbandov, AS.: Reproductive Physiology. W. H. Freeman and Co., New York, 1964. Indian Edition Taraporevala & Sons Pvt. Ltd., Bombay, 1970).
4. Nieschlag E. and Bchre H.M. TestorteroneAction-Deficiency-Sub- stitution. Springer-Verlag Berl in, 1996.
5. Nicschlag E. Habenicht UP. and Nieschlagss. Spermatogenesis-Fertilization-Contraception Springer-Verlag, Berlin, 1992.
6. Wilson J.D. and Foster D.W. Williams Text Book of Endocrinology W.B. Saunders Co., Philadelphia, 1992. Burger H. and Dkrester D. The testis. Raven Press, New York. 1989;
7. Negro-Vilar, A. Isidori A, Paulson J. Abdelmassih R. and Castro, P.P Andrology and Human Reproduction; Raven Press, New York, 1988.

8. Joy KP. Krishna A. and Haldar C: Comparative Endocrinology and Reproduction. Narosa Publishing House, New Delhi, 1999.
9. Thomas J .A., Endocrine Methods. Academic Press, New York, 1996.
10. Desjardins, C. and EwingL.L. Cell and Molecular Biology of the testis, Oxford University Press, New York, 1993.
11. Levy A and Lightman S. Endocrinology. Oxford University Press, Oxford, 1997.
12. Hadley, M.E., Endocrinology. Prentice Hall International, Inc. New Jersey, 2000.
13. Scientific, Publishers Ltd, 2001.

5. ENTOMOLOGY

PAPER-V : MORPHOLOGY AND PHYSIOLOGY

Duration : 3 Hrs. ***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 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.

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 physi-

ology. 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 post-embryonic development, types of larvae, pupae and metamorphosis, role of endocrine in growth and development, diapause viviparity and parthenogenesis.

5. ENTOMOLOGY

PAPER-VI: SYSTEMATICS, ECOLOGY AND APPLIED ENTOMOLOGY

Duration : 3 Hrs. ***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 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.

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.
   (a) Effect of physical factors.
   (b) Intro and interspecific relations.
   (c) Population dynamics.
   (d) Host-plant insect interactions.
   (e) Biochemical adaptations to environmental stress (Metamorphosis; Diapause, polymorphism etc.)
7. Concept of pest. How and why insects have become pests?
8. Life history, damage caused and control of major pests of :
   (a) Cash crops e.g. sugarcane, tobacco, and mustard.
   (b) Cereal crops e.g. wheat, paddy, millet, maize, sorghum, pulses.
   (c) Pests of vegetables, fruits and oil seed crops.
   (d) Cash fibre crops e.g. cotton, sunnhemp. etc.
   (e) Pests of medical and veterinary importance with reference to role of WHO and UNICEF. Insect borne diseases. (A preliminary idea)
   (f) Storage pests (Stored grains and milled products) with an elementary idea of different types of storage.
9. Insect control : Basic idea.
10. Various methods of insect control.
   (a) Prophylactic and cultural methods, Quarantine regulation.
   (b) Physical control.
   (c) Chemical control.
   (d) Biological control.
   (e) Insect pest management, its strategies and tools in IPM. Its relevance in insect pest control.
11. Chemistry and mode of action of insecticides. 12
   (a) Inorganic insecticides.
   (b) Organochlorine insecticides.
   (c) Organophosphorus compounds and carbonates.
   (d) Insecticides of plant origin.
   (e) Synthetic pyrethroids.
   (f) Insect growth regulatory compounds.
   (g) Microbial insecticides.
   (h) Chemosterilant, repellents, antifeedants.
   (i) Fumigants and fumigation.
12. Concept of I, II and III generation of insecticides.

12.1 A brief idea of appliances used for application of insecticides, hazards involved and safe handling of insecticides. 2
12.2 Development of resistance in insects to insecticides. 1
12.3 Insecticide synergists and antagonists. 2
12.4 Insecticide formulations and application technology. 2
12.5 Dynamics of environmental pollution. 2
12.6 Pesticides: their impact on wildlife and human health (bioaccumulation, biomagnification, biodegradation)
12.7 Microbial and environmental degradation of pesticides. 2

13. Forensic entomology with special reference to man and wildlife.
14. Beneficial insects: Silk worm, honeybee and lac insect and industries related to them.
15. Role of genetics in vector control.
16. Social insects, social organization, caste differentiation.

List of Practicals :

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) Grasshopper
   (c) Honeybee: Digestive and nervous system.
   (d) White grubs: Nervous system.
   (e) Housefly.
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 (wm.) 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-**

(a) Tribolium Sp.
(b) Rhizopertha Sp.
(c) Heliothis Sp.
(d) Corcyra Sp.
(e) Callosobruchus Sp.,
(f) Lasioderme serricorne, mosquito species.

7. **Testing of insecticides** : Bioassay methods.
8. **Study of prepared slides.**
   (a) Whole mounts of insects.
   (b) Histology.
   (c) Leg types.
   (d) Antennae types.
   (e) Types of mouthparts.
   (f) Wing types.
9. Microtomy (Internal organs of insects).
10. Study of seasonal abundance of crop-pest in nearby area.
11. Live demonstration of biological control using *Coccinella* or *Chrysopa.*
12. Role of hormones in metamorphosis (Ligature experiment with housefly larvae)
13. To study antennal grooming in cockroach.
14. To study the blood cells in insects.
15. To study meiosis and polytene chromosomes in insects.
16. To study the insects infestation in the grains.
17. To study the food preference of *Tribolium* or any other insect.

SCHEME OF ENTOMOLOGY PRACTICAL EXAMINATION

Duration : 5 Hrs. ***Max. Marks: 100***

1.	Major dissection	15 (12+3)
2.	Minor dissection/Permanent preparation.	5(4+1)
3.	Identification of Four insects (A to D) using taxonomic keys	16
4.	Exercise on Ecology/Physiology/Behaviour/Bioassay.	10
5.	Microtomy.	10
6.	Comment upon spots 1 to 8.	24
7.	Viva	10
8.	Record/Field work.	10
	Total	90

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. Churchill. 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 Agricutural entomology. Indian council of Agricultural Research, New Delhi. 1969.
6. Wigglesworth. VB.: The Principles of Insect 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. 1968.
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. Rinehart and Winston. New York. 1954.
12. Essig.E.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: Affliated East West press, Pvt.Ltd., New Delhi.
14. Frost, S.W. Insert Life and Insert 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. Little, V.A.: General and Applied entmology. Harper and Row. New York, 1960. (Indian Repint.: Oxford and IBH Publishing Co. New Delhi 1973.
18. Ross, H.H.: A Text Book of entomology. John Wiley and Sons Inc. New York. 1965.
19. The year book of Agriculture, U.S. Department of Agriculture, Washington, D.C.
20. Kilgore, W.W. and Dout, R.L.: Pest Control, biological, physical and selected chemical methods. Academic press, New York and London, 1967.
21. Nayar, K.K., K.K., Anantkrishnan, T.N. and David, B.V.: General and applied entomology. Tata McGraw-Hill Publishing company limited, Delhi,1976.
22. Dhaliwal, G.S.and Arora, Ramesh. Principles of insect. Pest management, National Agricultural Technology Information Centre, Ludhiana, 1976.
23. Kumar Ashok and Nigam, P.M.: Economic and applied Entomology. Emkay Publication, Post Box No. 9410, B-19, East Krishna Nagar, Delhi-110051.

6. ENVIRONMENTAL BIOLOGY

PAPER-V: ENVIRONMENTAL SCIENCE, ECOLOGICAL PRINCIPLE, WILDLIFE & CONSERVATION BIOLOGY

Duration : 3 Hrs. ***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 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

1. **Biomes**
    - 1.1 A-Terrestrial Biomes
        - 1.1.1 Desert
        - 1.1.2 Grassland: Prairies & Plains
        - 1.1.3 Tundra
        - 1.1.4 Temperate Needle leaf forests
        - 1.1.5 Deciduous and evergreen forests (Broad leaved)
        - 1.1.6 Topical moist Forest
        - 1.1.7 Tropical seasonal forest
        - 1.1.8 Biomes of India
    - 1.2 Aquatic Ecosystem
        - 1.2.1 Fresh water and Brackish water ecosystem
        - 1.2.2 Estuaries and wetland: Transitional communities
        - 1.2.3 Shoreline and Barrier island
        - 1.2.4 Oceanic island and reef
2. Biological Communities
    - 2.1 Critical factors & Tolerance limits
    - 2.2 Natural selection, Adaptation and evolution
    - 2.3 Ecological niche
3. Species interactions
    - 3.1 Predation
    - 3.2 Competition
    - 3.3 Symbiosis
4. Community Dynamics
    - 4.1 Productivity
    - 4.2 Abundance and diversity
    - 4.3 Complexity & connectedness
    - 4.4 Resilience & diversity
    - 4.5 Community structure
    - 4.6 Edges and boundaries
5. Communities in transition
    - 5.1 Ecological succession
    - 5.2 Introduced species and community change
6. Restoration Ecology
    - 6.1 Natural
    - 6.2 Restoring keystone species and ecological process
    - 6.3 Mitigation and replacement
    - 6.4 Creating a artificial ecosystem

7. Conservation of biodiversity
   - 7.1 Concept of biodiversity
   - 7.2 Causes of loss of biodiversity
   - 7.3 Productivity and diversity
   - 7.4 Conversion methods- In-situ & Ex-situ.
   - 7.5 Biodiversity conversion methods: Gene bank, intellectual property right and bio-safety protocol
8. Population dynamics
   - 8.1 Dynamics of population growth
     - 8.1.1 Exponential growth & doubling times
     - 8.1.2 Biotic potential
     - 8.1.3 Catastrophic declines and population oscillation
     - 8.1.4 Growth to a stable population
     - 8.1.5 Strategies of population growth
   - 8.2 Factors that increase or decrease population
     - 8.2.1 Natality, Fecundity & fertility
     - 8.2.2 Immigration
     - 8.2.3 Mortality and survivorship
     - 8.2.4 Age structure
     - 8.2.5 Emigration
   - 8.3 Factors: Regulate population growth
     - 8.3.1 Density independent factors
     - 8.3.2 Density dependent factors
9. Methods of population estimations of animal
   - 9.1 Census
   - 9.2 Sampling
   - 9.3 Indices, manipulation of indices
   - 9.4 Transect estimates
   - 9.5 Arial survey
   - 9.6 Belt transect
   - 9.7 Line transect estimate
   - 9.8 Mark recapture estimates
10. Restoration of wildlife populations by reintroduction-
    - 10.1 Captive breeding
    - 10.2 Soft and hard release
    - 10.3 Management of endangered species-reasons to preserve them
    - 10.4 Human factors leading to extermination/extinction of species, characteristics of endangered species.

11. Habitat analysis and evaluation-
    - 11.1 Reconnaissance type evaluation of habitat
    - 11.2 Permanent condition- trend transects vegetative analysis
    - 11.3 Forest range evaluation
    - 11.4 Wetland evaluation
    - 11.5 Wildlife evaluation
12. Environmental monitoring
    - 12.1 Physicochemical and biological monitoring
    - 12.2 Biological indicators of environmental changes
    - 12.3 Physiological adaptations of animals to their environment- effects of temperature, current, pressure
    - 12.4 Osmoregulation, aestivation, mimicry, camouflage, bioluminescence, parasitism, eco-location, migration, pheromones
13. Environmental degradation, role of men in changing the environment
14. Environmental awareness and education regarding conservation of wildlife.
    - 14.1 Wildlife protection legislation- acts and laws in India
    - 14.2 Environmental conservation ethics
15. Impact of tourism related activities on environment.
    - 15.1 Basic principles of ecotourism
    - 15.2 Ecological and conservation aspects of tourism
    - 15.3 Island ecology and tourism
    - 15.4 Effect of tourism related developments on ecology
    - 15.5 Pollution related to tourism
    - 15.6 Disposal of solid and liquid waste from tourist destination
16. Wildlife techniques- radiometry, photographic identification of animals etc.
17. Wildlife of India- reserves, management, diversity, special protection programmes

6. ENVIRONMENTAL BIOLOGY

PAPER-VI: ECOTOXICOLOGY, ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Duration : 3 Hrs. ***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 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.

1. Environmental Health and Toxicology
   - A. Types of Environmental Hazards
     1. Infectious organisms
     2. Chemicals (Pesticides, metals, solvents)
     3. Radiation
   - B. Movement, distribution and fate of toxins
     1. Bioaccumulation
     2. Biomagnifications
     3. Biotransformation (metabolic degradation and excretion)
   - C. Carcinogenesis, genetic toxicology, developmental toxicology and wildlife toxicology
2. Measuring toxicity
   - A. Animal testing:
     - (a) Acute, sub chronic and
     - (b) Chronic
     - (c) GLP
   - B. Environmental impact assessment with special reference to biotic environment
   - C. Risk assessment
   - D. Statistical analysis of data
3. Pollution

A. Air
   1. Natural sources of air pollution
   2. Human caused air pollution
   3. acid rain
   4. Climate: Topography and atmospheric processes
   5. Global warming: The green house effect, green house gases, potential effect of global warming
   6. Control of air pollution
   7. Ozone depletion

B. Water
   1. Types and effects of water pollution
      - Infectious agents
      - O_2 demanding waters
      - Plant nutrients and cultural eutrophication
      - Toxic inorganic and organic materials
      - Human waste disposal
      - Waste water treatment

4. Biogeochemical cycling
   - Carbon cycle
   - Nitrogen cycle
   - Sulfur cycle
   - Phosphorus cycle
   - Iron & other element

5. Biodeterioration Control and Soil, Waste, and Water Management
   - Control of Biodeterioration
   - Management of Agricultural soils
   - Treatment of Solid waste
   - Treatment of Liquid waste

6. Microbial Interaction with Xenobiotic and Inorganic Pollutants
   - Persistence and Biomagnifications of xenobiotic molecules
   - Polychlorinated Biphenyls and Dioxins
   - Synthetic Polymers
   - Microbial Interaction Interactions with some Inorganic
   - Acid mine drainage
   - Microbial Conversions of Nitrate
   - Microbial Methylations
   - Microbial Accumulation of Heavy Metals and radio nuclides

7. Biodegradability Testing and Monitoring the Bioremediation of Xenobiotic Pollutants
   - Biodegradability and ecological side effect testing
   - Biosensor Detection of Pollutants
   - Bioremediation
   - Environmental Modification for Bioremediation
   - Microbial seeding and Bioengineering approaches to the Bio remediation of Pollutants
   - Bioremediation of Marine Oil pollutant
   - Bioremediation of air pollutants
8. Microorganisms in Mineral and Energy Recovery and Fuel and Biomass Production
   - Recovery of metals
   - Recovery of Petroleum
   - Production of Fuels
   - Production of Microbial biomass
   - Single-cell protein production
9. Microbial Control of Pests
   - Controlling pest populations of plants and animals
   - Microbial controls of other animal pests
   - Microbial control of weeds and cyanobacterial blooms
   - Genetic engineering in biological control
   - Frost protection
   - *Bacillus thuringiensis* pesticides
   - Other applications

PRACTICAL EXERCISES

Paper-I

1. Visit to at least 3 biomes of India for the detail study: Student should submit the report on the study covering major fauna, flora and geography.
2. Determination of population density
3. Collection of flora (herbarium) & fauna (insect).
4. Visit to some of the few following natural habitats and wildlife sanctuaries-desert, mountain range, wetland, coastal habitat, forests wildlife sanctuaries of India and especially Rajasthan. (students are required to submit the joint report on the field visit s undertaken by them)

5. Identification of mammalian species using hair imprinting, electrophoresis to identify the species of wildlife, collection of molts of birds.
6. Determination of population density of small mammals using transect method
7. Collection and identification of insect fauna of wildlife habitats.
8. Collection of fecal matter samples of herbivore from wildlife habitat to study the parasitic load.
9. Determination of home range of birds/mammals.
10. Study of herd structure of herbivore population.
11. Study of hierarchy in monkey population.

Paper-II

1. Water analysis for fresh and waste water for physicochemical properties and planktons.
2. Air quality monitoring.
3. Bioassay of polluted water using microbes or any other higher animal (fish).
4. Pesticide residue analysis using GC and TLC techniques.
5. Water pollution detection (microbial).
6. Trips to natural habitat and man made habitats to study the human impact on environment.
7. Project work.
8. Electrophoretic analysis of proteins.
9. Enumeration and isolation of soil microorganisms, agar plate technique, bacteria, fungi and protozoa.
10. Bacterial examination of water for portability, microorganism, E-coli, staphylococci faecalis as indicators of pollution. MPN index- IMVIC test- Endo agar.
11. Testing of water/soil/sewage for physicochemical parameters including COD and BOD.
12. Field trip to ponds/coastal/other treatment (water or industrial water) plants.

PRACTICAL EXAMINATION SCHEME

Duration - 8 hrs. **Max. Marks–100**

	Exercise	**Marks**
1.	Bioassay Exercise	5
2.	TLC/Paper chromatography : Pesticide/toxicant	10

	residue analysis	
3.	Electerophoresis : Analysis of proteins	10
4.	Bacterial examination of water (MPN index/ IMVIC tests)/ Microbiological exercise agar plate technique	10
5.	Project Report	15
6.	Water/Waste water analysis for physiochemical properties	10
7.	Determination of population density	5
8.	Spotting	15
9.	Record	10
10.	Viva-Voce	10
		Total=100

7. FISH BIOLOGY

PAPER-V: FISH BIOLOGY

Duration : 3 Hrs. ***Max. Marks: 100***

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 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.

Total No. of Lectures: 90

1. Classification of fishes with special reference to evolutionary trends and adaptations. 3
2. Integument and exoskeleton. 3
3. Fins : Types of fins, structure, modifications and functions of fins. 3
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

5. Food, feeding habits and feeding adaptations/behaviour; structure of the alimentary canal and physiology of digestion and absorption. 3
6. Planktons: Classification, common organisms and their importance; algal bloom, nutrient cycle, trophic levels and energy flow. 5
7. Blood vascular system : Structure of the heat; principal blood vessels and circulation of blood (elasmobranch, teleost and Dipnoi) 5
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. 5
9. Air breathing fishes; causative factors and structural adaptations. 3
10. Structure and functions of the kidney; nitrogenous end products and pattern of their excretion. 3
11. Water and electrolyte regulation in marine, freshwater and euryhaline fishes.
12. Structure and functions of the swimbladder. 2
13. Study of feeding habits of fish through qualitative and quantitative analysis of gut contents of herbivorous, carnivorous and omnivorous species. 4
14. Nervous system: Structure and functions of the central, peripheral and autonomic nervous systems; anatomy and function of the Mauthner neurons. 4
15. Structure and functions of the sense organs : 5
    15.1 Eye; visual pigments and vision.
    15.2 Chemoreceptors: Olfactory and gustatory; biological significance of chemoreception.
    15.3 Labyrinth.
    15.4 Mechanoreceptors (lateral line organs.)
16. Structure and physiology of the endocrine organs and tissues:
    16.1 Pituitary. 12
    16.2 Thyroid.

16.3 Gonads.
16.4 Adrenal.
16.5 Endocrine pancreas.
16.6 Ultimobranchial.
16.7 Caudal neurosecretory cells and urophysis.
16.8 Pineal.

17. Reproduction: Organs of reproduction; modes of reproduction; oviparity, viviparity hormonal and environmental regulation of reproduction. 5
18. Reproductive behaviour: Secondary sexual characters, nest building and parental care. 2
19. Development: Types of eggs; fertilization; hatching and metamorphosis. 2
20. Adaptations: Coloration, sound production, electric, organs, luminescent organs (location, structure, physiology and biological significance). 2
21. Adaptations in deep sea, hill-stream and cave-dwelling fishes; freezing avoidance in arctic and antarctic fishes. 3
22. Migration; its types and causes. 2
23. Fish pathology: Symptoms, etiology, prophylaxis and treatment of common diseases and pathological conditions in cultivable fish. 2
24. Setting-up and maintenance of an aquarium. 2
25. Fish products and byproducts: Liver oil, body oil, meal, fish manure, guano, glue, isinglass, roe (caviar), fins and leather. 2

7. FISH BIOLOGY
PAPER-VI: AQUACULTURE AND FISHERIES

Duration : 3 Hrs. ***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 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.

Total No. of Lectures: 90 hrs.

1. Definitions of (a) inland, (b) marine (c) capture (d) culture fisheries. 3
2. Riverine fisheries: Ecology and fisheries of the major river systems; effects of dams and barrages on riverine fisheries. 6
3. Reservoir fisheries: Location, ecology and fisheries of some important reservoirs; development, exploitation and management of reservoir freshwater fisheries. 6
4. Coldwater fisheries: Ecology of high altitude streams, lakes and reservoirs; present status and scope for development of important coldwater fisheries. 6
5. Estuarine fisheries: Ecology and fishery resources of major estuaries; potential and management of estuarine fisheries. 6
6. Marine fisheries :
   - 6.1 Ecology and general survey of marine capture fisheries with special reference to sardine, mackerel, Bombay duck and pomfret. 6
   - 6.2 Offshore and deep sea fishery potential in EEZ (Exclusive Economic Zone) 1
7. Estimation of fecundity and population. Population dynamics and fishery catches. 3
8. Growth and age; environmental factors and methods. 3
9. Crustaceans and Molluscan fisheries (Marinewater, Brackishwater and Freshwater). 3
10. Methods of Fishing: Crafts (non-mechanised and mechanised) and gears used in India for fishing in inland and marine water; recent advances in fishing methods, electrical fishing; light fishing, fish finders (Eco-sounder and sonar) and their use. 3
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. 5
12. Fishery management; fish yield, effect of fishing on yield and optimum catch; concept of a rational fishery. 3

13. Ecology and Productivity of freshwater lake and perennial fish-pond indices of productivity; physical and chemical characteristics of water, nature and fertility of the soil. 3
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. 3
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. 7
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. 7
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. 6
18. Cold-water culture of trout: mahseer, culture method and management.
19. Larvivorous fishes and their importance. 2
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. 2
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. 2

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 Marine 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) 2

List of Practicals Exercises

1. Study of distingueshing features, identification and classification of specimens of important specis of fish available in the museum; Collection of local fish fauna and its identification upto the specis level using taxonomic keys.
2. **Anatomy and Histology:**
   (a) Study of anatomy of teleost represented by the catfirh wallago atteu:
   External anatomy and gills, Uiscera, alimentary canal and urinogivetal organs; musculature for gill ventilalion, and feeding; eye muscles and their innervation, 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, scales (Placoid, cycloid and ctenoid), gill filament and olfaetory lamella.
   (c) Dissection of air-breathing organs and thier blood supply in Anabas testudineus, Clarias batrachus, He tropneustes fossilis and channa sp.
   (d) Study of fish anatomy and histology through available slides.
3. **Preparation of microscopic slides of stained sections** of following organs/tissues/ structures from an adult teleost for their histological study of liver, intestine, kidney, testis, Ovary, gill, pituitary, thyroid tissue, head kidney (for interrenal and chromaffin cells).

4. ***Physiology and biochemistry.***
   - 4.1 Study of the effect of epinephrine, NaCl and KCl on fish chromatophores.
   - 4.2 Study of changes in chromatophores of fish kept against white (light) and black (dark) backgrounds for protracted periods.
   - 4.3 Determination of the rate of oxygen consumption (Winkler method) in a water breathing fish at different temperatures.
   - 4.4 Determination of the rate of ammonia and urea excretion in fish.
   - 4.5 Estimation of protein, fat, ash and water contents in fish muscle.
   - 4.6 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 common weeds, predatory fishes and harmful insects in a fresh water fish pond; estimation of primary productivity in a freshwater 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, tur-

bidity, 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

1.1 A visit to a fish farm/fish seed production centre.

1.2 3 to 4 day tour to study various fisheries activities at selected centres/sites.

Scheme of Practical Examination **Max. Maks 100**

1.	Major dissection	10+5=15
2.	Minor dissection/ slide preparation/ species identification	
3.	Identification and comments on spots (1-8)	24
4.	Microtomy procedure and preparation of slides	10
5.	Plankton identification/primary productivity/ water analysis	8
6.	Physiology/biochemistry	10
7.	Determination of age / growth / maturity stage/ GSI	5
8.	Record / Field work	10
9.	Viva-voce.	10
	Total	**100**

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. Langler, K.F. : Icthyology, 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.

8. RADIATION BIOLOGY

PAPER-V: BASICS OF RADIATION

Duration : 3 Hrs. ***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 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.

1. Atomic Structure
   - 1.1 Theories of atomic structure.
   - 1.2 Isotopes, isomers and isobars.
   - 1.3 Mass Number and Atomic mass.
   - 1.4 Sub-atomic particles.
   - 1.5 Excitation and ionization.
   - 1.6 Nuclear forces and nuclear structure
2. Types of Radiation
   - 2.1 Nuclear Radiation.
   - 2.2 X-rays-characteristics, production and uses.
3. Radioactivity
   - 3.1 Natural radioactivity.
   - 3.2 Artificial radioactivity.
   - 3.3 Half-life.
   - 3.4 Natural decay series.
   - 3.5 Background radiation.
4. LET and RBE
5. Radiation Dosimetry
   - 5.1 Units of radiation and radioactivity.
   - 5.2 X-rays dosimetry.
   - 5.3 Radiation weighting factors and equivalent dose.
   - 5.4 Tissue weighting factor and effective dose.
   - 5.5 Cumulative doses.
   - 5.6 External and internal dosimetry.

- 5.7 Microdosimetry.
- 5.8 Maximum Permissible Dose (MPD)

6. Detection and measurement of radiation
   - 6.1 Ionization chamber.
   - 6.2 Scintillation detectors.
   - 6.3 G.M. counter.
   - 6.4 Proportional counter.
   - 6.5 Gamma ray spectrophotometer.
   - 6.6 Radioautography, RIA.
7. Radiation chemistry
   - 7.1 Radiolysis of water.
   - 7.2 Hydrogen peroxide formation.
   - 7.3 Reactions in aqueous organic solutions.
   - 7.4 Direct and indirect effects.
   - 7.5 Oxygen effect.
8. Sources of Radiation Hazards
   - 8.1 Natural sources.
   - 8.2 Artificial sources.
   - 8.3 Sealed and unsealed sources.
   - 8.4 External radiation hazards.
   - 8.5 Internal Radiation hazards.
9. Radiation Monitors
   - 9.1 Personnel monitoring equipments.
   - 9.2 Film badge.
   - 9.3 Pocket dosimeter.
   - 9.4 Thermo Luminescence Dosimetry (TLD)
   - 9.5 Area monitoring.
10. Radioactive Contamination and Decontaminations
    - 10.1 Source of contamination.
    - 10.2 Control of contamination.
    - 10.3 Contamination monitoring.
    - 10.4 Decontamination
11. Radioactive waste management
    - 11.1 Characteristics of radioactive waste.
    - 11.2 Management of nuclear waste.
    - 11.3 Discharge of wastes.

PAPER-VI : RADIATION EFFECTS

Duration : 3 Hrs. ***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 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.

1. Interaction of radiation with matter.
   - 1.1 Direct effects of ionizing radiation.
   - 1.2 Indirect effects of ionizing radiation (photoelectric effect, Compton Effect, pair production).
   - 1.3 Bremsstrahlung effects.
   - 1.4 Interaction of neutrons.
   - 1.5 Nuclear fission and fusion (production of isotopes, nuclear reactors and accelerators).
2. Cellular radiobiology
   - 2.1 Apoptosis.
   - 2.2 Reproductive cell death.
   - 2.3 Survival curves.
   - 2.4 Radiosensitivity of cell cycle phases.
   - 2.5 Factors influencing radio sensitivity (oxygen effect & chemical modifiers).
   - 2.6 Classification of mammalian cell sensitivity.
   - 2.7 Effects of radiation on macromolecules including repair (Nucleic acids, Proteins).
3. Acute radiation effects
   - 3.1 Concept of LD50.
   - 3.2 Central nervous system syndrome.
   - 3.3 Gastro-intestinal syndrome.
   - 3.4 Bone marrow syndrome.
   - 3.5 Skin reactions.
4. Delayed effects of radiation

4.1 Stochastic and deterministic effects.
4.2 Radiologic aging.
4.3 Life shortening.
4.4 Radiation carcinogenesis.

5. Radiation effects on embryo and foetus
6. Radiation immunology
   6.1 Immunity response.
   6.2 Radiation as immunosuppressive agent.
   6.3 Long term changes in the immunological reactivity of the irradiated organisms.
7. Cytogenetic effects of radiations.
   7.1 Chromosomal aberrations.
   7.2 Micronuclei induction.
   7.3 Radiation mutations.
8. Radiation Hormesis.
   8.1 Evolution of current radiation paradigms.
   8.2 Epidemiological evidence.
   8.3 Experimental studies and adaptive response.
9. Radiation hazard evaluation and control
   9.1 Control of external hazards.
   9.2 Control of internal hazards.
   9.3 Exposure rate constant.
10. Radiation Accidents (special reference to Rajasthan-Pokharan I&II)
11. Radiation safety and regulatory aspects
   11.1 Radiographic installations.
   11.2 Enclosed installations.
   11.3 Field installations.
   11.4 Personnel management.
   11.5 Source storage facilities.
   11.6 Safe work practice.
   11.7 Re-commendations of National/International statutory bodies.

LIST OF PRACTICAL EXERCISES

Radiation Biology

1. Knowledge and use of the various instruments. Geiger-Muller counters. Decade Scalar, Scintillation counters (Crystal and Liquid), Survey meter, Single-channel gamma spectrometer, Actigraph system, Cobalt camera.
2. Finding out the operating voltage of the G. M. tube.
3. Calculation of Inverse Square Law.
4. Determination of the resolving time of the G.M. tube.
5. Absorption of b and gamma rays.
6. Determination of self-absorption factor.
7. Determination of backscattering factors.
8. Finding out the physical half-life of a given isotope:
   (a) Single isotope method.
   (b) From a mixture of two isotopes.
9. Autoradiography
   (a) Liquid-emulsion method.
   (b) Stripping film method.
10. Histopathological, histochemical and biochemical studies of various tissues after external and Internal irradiation.
11. Personnel monitoring. Use of G.M. survey meter, Film badge, and Room contamination monitor.
12. Study of permanently prepared histopathological slides.
13. Decontamination of contaminated material.
14. Visits to the Radiology Department, S.M.S. Medical College, Jaipur, Rajasthan, Atomic Power Project, Kota and Bhabha Atomic Research Centre, Mumbai.
15. Class Record.
16. Viva-voce.

SCHEME OF PRACTICAL EXAMINATION

1. Major exercise (1) **24 marks**
2. Minor exercise (1) **16 marks**
3. Preparation and study of a histopathological slide/ histochemical/ biochemical estimation of various macromolecules in different

tissues (Proteins, glycogen, cholesterol, Nucleic acids etc.) **16 marks**

4. Spotting (8) **24 marks**
5. Viva **10 marks**
6. Record **10 marks**

9. REPRODUCTIVE BIOLOGY

PAPER-V: ENDOCRINE GLANDS AND REGULATORY PROCESSES

Duration : 3 Hrs. ***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 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

1. Endocrine glands: An overview. 1
2. Biochemical nature of hormones. 2
3. Mechanism of hormone actions. 5
4. Structure and nomenclature of steroid hormones, steroidogenesis. 5
5. The female reproductive system: Comparative anatomy and physiology of the mammalian and sub mammalian ovary and ductal system. Follicular growth, kinetics and atresia, ovarian hormones, two cell theory of estrogen biosynthesis. Autocrine, Paracrine and endocrine regulation of ovarian functions. 12
6. The male reproductive system: Comparative anatomy and physiology of the mammalian and sub mammalian testis, epididymis and the sex accessory glands; Functional organization of testis, spermatogenic cycle. Testicular androgens, autocrine, paracrine

and endocrine regulation of testicular functions. Semen and its biochemical nature. 12

7. Regulation of reproduction 10
   - 7.1 The pituitary gland: Functional cytology, adenohypophyseal hormones, their chemistry and physiology.
   - 7.2 **The Hypothalamus and its neurosecretory centres: Structure** of neurosecretory cells, the hypothalamic principles: synthesis, storage, release and chemistry.
   - 7.3 The phenomenon of neuroendocrine integration and the hypothalamo hypophyseal gonadal axis.
8. Role of thyroid, pineal and adrenal glands in reproduction. 7
9. Breeding seasons and reproductive cycles. 3
10. Hormonal regulation of reproductive behaviour. 3
11. Biology of Sex-determination and Sex-differentiation. 3
12. Biology of spermatozoa and ovum : structure, development and function. 4
13. Fertilization: Pre-fertilization events, biochemistry of fertilization and post-fertilization events. 4
14. Implantation and its hormonal regulation, delayed implantation 3
15. Placenta as an endocrine tissue: foeto-placental unit. 2
16. Gestation and its hormonal regulation 2
17. Parturition and its hormonal regulation. 2
18. The mammary gland : Endocrinology of lactation. 2
19. Prostaglandins: Chemistry, mechanism of action and their role in reproduction. 4
20. Miscellaneous factors affecting reproduction : nutrition, light, temperature, pheromones, environmental disruptors. 4

9. REPRODUCTIVE BIOLOGY
PAPER-VI: REPRODUCTIVE TECHNOLOGICS

Duration : 3 Hrs. ***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 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.

1. Fundamental aspects of control of fertility in males : 14
   - 1.1 Mechanical.
   - 1.2 Surgical.
   - 1.3 Chemical.
   - 1.4 Immunological methods.
2. Fundamental aspects of control of fertility in females : 14
   - 2.1 Natural.
   - 2.2 Mechanical.
   - 2.3 Surgical.
   - 2.4 Chemical.
   - 2.5 Immunological.
   - 2.6 Emergency contraception.
3. Control of fertility in Insects. 3
4. Induced spawning in Fishes. 2
5. Techniques for improvement of breeding Farm animals. 4
6. Anatomy and physiology of the endocrine and neuroendocrine structures of annelids, arthropods and Mollusca with special reference to their role in reproduction. 10
7. Reproductive dysfunctions in males and females. 6
8. Diagnosis of male infertility : 6
   - 8.1 Semen analysis: Physical examinations, microscopic examinations, biochemical analysis, Immunological tests.
   - 8.2 Sperm function tests: Sperm mitochondrial Hypo-osmotic swelling test, acrosome, reaction, Zona binding assays, Acrosome intactness test, and hamster- oocyte penetration test.
   - 8.3 Endocrinological diagnosis.
9. Diagnosis of female infertility : 6
   - 9.1 Monitoring of ovarian and reproductive cycles.

9.2 Endometrial biopsy.
9.3 Ductal blockage.
9.4 Endocrine diagnosis.

10. Assisted Reproductive Technology (ART). 8
10.1 Super ovulation, oocyte collection.
10.2 Collection and preparation of sperm for assisted fertilization.
10.3 Insemination.
10.4 In vitro fertilization and related techniques (IVF, GIFT, ZIFT, TET, ICSI).
11. Cryopreservation of semen, oocytes and embryos. 2
12. Cloning, transgenic animals. 2
13. Teratological effects of Xenobiotics. 2
14. Pre-natal diagnosis. 1
15. Impact of aging, hormone replacement therapy. 3
16. Hormonal bioassay : 7
16.1 ELISA.
16.2 Radio Immuno assay (RIA).
16.3 Radioreceptor binding assay.

LIST OF PRACTICAL EXERCISES

Practicals:

1. Dissection of male and female reproductive systems.
2. Histology of the genital organs in normal and pathological conditions (Microtomy).
3. Monitoring of the exocrine and endocrine functions of gonads. (Vaginal smear, sperm function tests)
4. Biochemical investigations of the reproductive glands with special reference to their markers.
5. Surgical procedures in reproduction.
6. Induction of superovulation and collection of oocytes.
7. Demonstration of *in vitro* fertilization (GIFT, ZIFT, TET, ICSI, etc.)
8. Hormonal bioassays.
9. Pregnancy test.
10. Study of permanent histological slides : Various endocrine glands, male and female reproductive systems.

Scheme of practical examination

Duration : 5 Hrs. **Max. Marks : 100**

1.	Dissection of male and female reproductive organs surgical procedures.	12
2.	Monitoring of exocrine and endocrine functions of gonads.	10
3.	Biochemical investigations of marker parameters.	12
4.	Microtomy.	12
5.	Hormonal bioassay Pregnancy test, *in vitro* fertilization (GIFT, ZIFT, TET, ICSI)	10
6.	Spots (1-8)	24
7.	Viva-Voce.	10
8.	Class-Record.	10
	Total	**100**

UNIVERSITY OF RAJASTHAN JAIPUR

RULES FOR THE AWARD OF GRACE MARKS

A. UNDER GRADUATE/POST GRADUATE (MAIN/SUPPLEMENTARY) EXAMINATION UNDER THE FACULTIES OF ARTS, FINE ARTS, SCIENCE, COMMERCE, SOCIAL SCIENCE, EDUCATION, MANAGEMENT, HOMOEOPATHY, LAW, AYURVEDA AND ENGINEERING & TECHNOLOGY.

Grace marks to the extent of 1% of the aggregate marks prescribed for an examination will be awarded to a candidate failing in not more than 25% of the total number of theory papers, practicals, sessionals, dissertation, viva-voce and the aggregate, as the case may be, in which minimum pass marks have been prescribed; provided the candidate passes the examination by the award of such Grace Marks. For the purpose of determining the number of 25% of the papers, only such theory papers, practicals, dissertation, viva-voce etc. would be considered, of which, the examination is conducted by the University.

N.B. : If 1% of the aggregate marks of 25% of the papers works out in fraction, the same will be raised to the next whole number. For example, if the aggregate marks prescribed for the examination are 450, grace marks to the extent of 5 will be awarded to the candidate, similarly, if 25% of the total papers is 3.2, the same will be raised to 4 papers in which grace marks can be given.

General

1. A candidate who passes in a paper/practical or the aggregate by the award of grace marks will be deemed to have obtained the necessary minimum for a pass in that paper/practical or in the aggregate and shown in the marks sheet to have passed by grace. Grace marks will not be added to the marks obtained by a

candidate from the examiners nor will the marks obtained by the candidate be subject to any deduction due to award of grace marks in any other paper/practical or aggregate.

2. If a candidate passes the examination but misses First or Second Division by one mark, his aggregate will be raised by one marks so as to entile him for the first or second division, as the case may be. This one mark will be added to the paper in which he gets the least marks and also in the aggregate by showing + 1 in the tabulation register below the marks actually obtained by the candidate. The marks entered in the marks-sheet will be inclusive of one grace mark and it will not be shown separately.

3. Non appearance of a candidate in any paper will make him ineligible for grace marks. The place of a passed candidated in the examination list will, however, be determined by the aggregate marks he secures from the examiners, and he will not, by the award of grace marks, become entitled to a higher division.

4. Distinction won in any subject at the examination is not to be forfeited on the score that a candidate has secured grace marks to pass the examination.

Note: The grace marks will be awarded only if the candidate appears in all the registered papers prescribed for the examination.