



University of Rajasthan Jaipur


SYLLABUS

M.Sc. ZOOLOGY

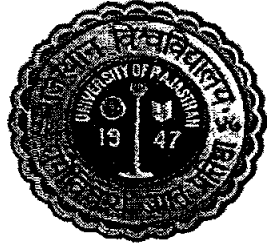
(Annual Scheme)

M.Sc. (Previous) Examination 2025

M.Sc. (Final) Examination 2026


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M.Sc.

ZOOLOGY

(ANNUAL SCHEME)

M.Sc. (Previous) Examination 2023-2024

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UNIVERSITY OF RAJASTHAN

UGC CURRICULUM FOR POSTGRADUATES

M.Sc. Zoology 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	Biostatistics and Population Genetics

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

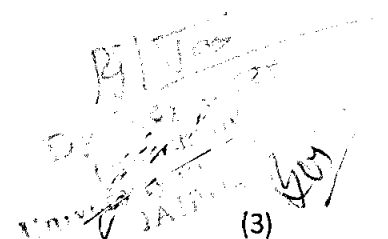
1. Definition and basic concepts of biosystematics and taxonomy 10
 - 1.1 Historical resume of systematics.
 - 1.2 Importance and applications of biosystematics in biology.
 - 1.3 Manual basis of histo-systematics-different- attributes.
 2. Trends in biosystematics: Concepts of different conventional and newer aspects 14
 - 2.1 Behavioural Taxonomy
 - 2.2 Chemotaxonomy
 - 2.3 Cytotaxonomy
 - 2.4 Molecular taxonomy
 - 2.5 Numerical 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
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- 4.1 Dimensions of speciation – Types of lineage changes; Production of additional lineage.
- 4.2 Mechanisms of speciation, Speciation in panmictic and apomictic 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 categories.
- 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 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 taxa.
6. Evaluation of biodiversity indices 10
- 6.1 Shannon-Weinner index, dominance index.
- 6.2 Similarity and dissimilarity index
- 6.3 Association index

Recommended Books (All latest editions)

1. Avise, J.C., Molecular Markers, Natural History and Evolution. Chapman Hall, New York.
2. Kato, M., The Biology of Biodiversity, Springer.
3. Mayer, E., Principles of Systematic Zoology, McGraw Hill Book Company, New York.
4. Simpson, G.G., Principle of Animal Taxonomy. Oxford, IBH Publishing Company.
5. Tikadar, B.K., Threatened Animals of India, ZSI Publication, Calcutta.
6. Wilson, E. O., The Diversity of Life. W.W. Northern & Company.
7. Wilson, E.O., Biodiversity. Academic Press, Washington.



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Paper II: STRUCTURE & FUNCTION OF INVERTEBRATES

3 Hours duration

Max. Marks: 100

Periods : 80

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, Rhynchocoela, Protostomes, Deuterostomes)
 - 8.2 Organization and general characters.

Recommended Books

1. Hyman, L.H., The Invertebrates, Vol. 1, Protozoa through Ctenophora, Mc.Graw Hill Company, New York.
2. Hyman, L.H., The Invertebrates, Vol. 2, Mc.Graw Hill Company, New York.
3. Hyman, L.H., The Invertebrates, Smaller Coelomate Groups, Vol. 5, Mc.Graw Hill Company, New York.
4. Hyman, L.H., The Invertebrates, Vol. 8, Mc.Graw 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. McMillan Company Ltd., London.
8. Cad, G.P., Animal Parasitism, Prentice Hall Inc., New Jersey.
9. Sedwick, A., Student Text Book of Zoology, Vol. I, II, and III, Central Book Depot, Allahabad.
10. Parker, T.J., Haswell, W.A., Text Book of Zoology, MacMillan Co., London.

PAPER III: MOLECULAR BIOLOGY & BIOTECHNOLOGY

Duration: 3 Hours

Max. Marks: 100

Periods : 80

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|---|----|
| 1. DNA | 6 |
| 1.1 Equivalence rule | |
| 1.2 DNA structure: Primary & Secondary, Unusual secondary structures (slipped & cruciform, triple helix, tetraplex and G-quadruplex). | |
| 1.3 Packaging of DNA: Nucleosome, solenoid & scaffold | |
| 2. DNA replication | 12 |
| 2.1 Prokaryotic and eukaryotic DNA replication | |
| 2.2 Mechanics of DNA replication | |
| 2.3 Enzymes and accessory proteins involved in DNA replication | |
| 3. Transcription | 10 |
| 3.1 Prokaryotic transcription | |
| 3.2 Eukaryotic transcription | |
| 3.3 RNA polymerases | |
| 3.4 General and specific transcription factors | |
| 3.5 Regulatory elements and mechanisms of transcription regulation | |
| 3.6 Transcription termination | |
| 3.7 Transcriptional and post-transcriptional gene splicing | |

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4.	Post-transcriptional modifications in RNA	10
4.1	Cap formation	
4.2	End processing and polyadenylation	
4.3	Splicing, editing	
4.4	Nuclear export of mRNA.	
4.5	RNA stability	
5.	Translation	
5.1	Genetic code	
5.2	Prokaryotic and eukaryotic translation	
5.3	Translation machinery	
5.4	Mechanisms of initiation, elongation and termination	
5.5	Regulation of translation	
5.6	Co-and post-translation modifications of proteins.	
6.	Recombination and repair	
6.1	Holliday junction, gene targeting, gene disruption	
6.2	FLP/FRT and Crelox recombination	
6.3	RecA and other recombinases	
6.4	DNA repair mechanisms (Radiation damage, Direct reversal, Oxidative damage, Alkylation, Base excision repair, Nucleotide excision repair, Mismatch repair, ds break repair, SOS response, Translesion DNA system	
7.	Molecular mapping of genome	10
7.1	Genetic and physical maps	
7.2	Physical mapping and mapbased cloning	
7.3	Southern and fluorescence, <i>in-situ</i> hybridization for genome analysis	
7.4	Molecular markers in genome analysis, RFLP, RAPD, AFLP, DNA fingerprinting, single nucleotide polymorphism (SNPs), Sequence tagged site (STS)	
7.5	Application of RFLP and forensic disease prognosis, genetic counselling, pedigree varietal etc. Analysis, Animal tracking and poaching, germplasm maintenance and taxonomy.	
8.	Human Genome project, map project, the encode project	10
8.1	Production Recent Technologies of transgenic animals and Knock out and its applications	
8.2	Embryonic stem cells and its applications	
8.3	Care and breeding of experimental animals including bioethics	
9.	Embryo technology	10
9.1	Superovulation, cryopreservation of spermatazoa.	
9.2	<i>In Vitro</i> fertilization and embryo transfer.	
9.3	Embryo sexing and cloning	

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- 9.4 Chimera formation.
- 9.5 Gene transfer through embryo transgenesis.
- 9.6 Surrogacy and ethics.
- 9.7 Assisted Reproductive Technologies-ICSO, GIFT, ZIFT, TET
- 9.8 Prenatal diagnosis and genetic counselling.

Recommended Books

- 1. Albert, B., Bray, D.D., Lewis, J., RafifM., Roberts, K, Walson, J.D., Molecular Biology of the. Cell. Garland Publishing Company, Inc., New York.
- 2. Benjamin, Lewin, Gene VIII, Oxford University Press, U.K
- 3. Brown, T.A. (Ed.), Molecular Biology Labfax, Vol. 1, Bio Scientific Publishers Ltd, Oxford.
- 4. Dabre, P.D., Introduction to Practical Molecular Biology, John Wiley & Sons Ltd., New York.
- 5. Darnell, J., Lodish, H. and Baltimore, D.; Molecular Cell Biology, Scientific American Books, Inc., USA.
- 6. Karp, G Cell and Molecular Biology, Concepts and Experiments, John Wiley & Sons, Inc., New York.
- 7. Meyers, R.A. (ed.), Molecular Biology and Biotechnology. A Comprehensive Desk Reference. VCH Publishers, inc, New York.
- 8. Sambrook, J., Fritsch, E.F. and Maniatis, T Molecular Cloning: A Laboratory Manual. Cold Spring HarborLaboratory Press, New York.
- 9. Watson, J.D., Hopkins, N.H., Roberts, J.W., Steiz, J.A., Weinef, A.M.; Molecular Biology of Gene. The Benjamin Cummings Pub. Co., Inc., California.

PAPER IV: GENERAL PHYSIOLOGY

Duration: 3 Hours

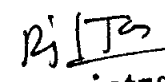

Max. Marks: 100

Periods : 80

- 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 Adaptationsto very cold environments
- 2. Ionic andOsmotic Balance 8
 - 2.1 Osmoregulation vs. Osmoconfirming

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✓	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 Role of haemoglobin	
	3.3 Responses to altitude and hypoxia	
	3.4 Swim bladder inflation in fish	
	3.5 Regulation of body pH	
	3.6 Gas transfer in air and water, gas exchanger design and function	
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
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- 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, testis, ovary)
- 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.

Recommended Books

1. Barrington, E.J.W., General and Comparative Endocrinology Claredon Press, Oxford.
2. Dejours, P.L., Bolis, L. Taylor, C.R., Weibel, E.R. (eds.); Comparative Physiology: Life in Water or Land, Liviana Press, Podova, Italy.
3. Eckert, R.W.H.; Animal Physiology, Mechanisms and Adaptations, Freeman and Company, New York.
4. Fochachka, P.W. and Somero, G.N.; Biochemical Adaptation, Princeton, New Jersey.
5. Gorbman, A., Dickhoff, W.W., Vigna, S.R., Clark, H.B., Ralpls, C.L.; Comparative Endocrinology, Wiley-Interscience Publication, New York.
6. Hill, R.W., Wyse, G.A., Anderson, M.; Animal Physiology, Sinauer Associates, Inc, Publishers, Sunderland, USA.
7. Hoar, W.S.; General and Comparative Animal Physiology, Prentice Hall of India.
8. Johnson, I.A., Bennett, A.F. (eds.); Animal and Temperature, Phenotypic and Evolutionary Adaptations, Cambridge University Press, Cambridge, U.K.
9. Louw, G.N.; Physiological Animal Ecology, Harloss, U.K.
10. Martin, C.R., Endocrine Physiology, Oxford University Press.
11. Newell, R.C. (ed); Adaptation to Environment: Essays on the Physiology of Marine Animals. Butter Worths, London, U.K.
12. Prosser, C.L.; Environmental and Metabolic Animal Physiology, Wiley-Liss, Inc, New York.

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- 13. Schemadt Nelsen; Animal Physiology: Adaptation and Environment. Cambridge University Press.
- 14. Strand, F.L.; Physiology: A Regulatory Systems Approach, Macmillan Publishing Co., New York.
- 15. Townsend, C.R. and Cawlow. P.; Physiological Ecology: An Evolutionary Approach to Resource Use, Blackwell, Sci. Publication, Oxford, U.K.
- 16. Vander, A.J., Sherman, J.H., Luciano, D.S.; Human Physiology, McGraw-Hill Publishing Company, New York.
- 17. Williams, R.H., Text Book of Endocrinology, W.B. Saunders.
- 18. Willmer, Stone, P.G and Johnson, I.; Environmental Physiology, Blackwell Sci. Publication, Oxford, U.K.


PAPER V: BIOCHEMISTRY

Duration: 3 Hours


Max. Marks: 100

Periods : 80

- | | | |
|----|---|---|
| 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 | |
| | 4.1 Protein folding and dynamics. | |


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- 4.2 Folding overview: Levinthal paradox.
- 4.3 Condensation and molten globules.
- 4.4 Ramchandaran plots and amino acid propensities.
- 4.5 Catalysis and assistance.
- 4.6 Amino acid sequence variation and membrane protein folding.
- 4.7 Chaperonin-assisted protein folding.
5. Allostery(Hemoglobin), Myoglobin structure and oxygen binding 3
- 5.1 Hemoglobin subunits co-operativity, 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 functions.
- 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 thiamine, riboflavin, folic acid and B₁₂.
- 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 acids 5
- 10.1 DNA and RNA helical geometries (A-Z), banding, deformation.
11. Nucleic acid analysis: DNA and RNA sequencing, determination of modified nucleotides. 4
12. RNA catalysis 3
- 12.1 Chemistry and structure of ribozymes.


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- 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

Recommended Books

1. Alberts R.H., Frey P.A. and Jencks W.P. Biochemistry Jones. & Bartlett Publisher, Boston/London. 1992.
2. Champe, P.C., Harvey, R.A.; Lippincott's Illustrated Reviews Biochemistry, Lippincott Williams & Wilkins, Philadelphia.
3. Deb A.C. Fundamentals of Biochemistry, New Book Agency Pvt. Ltd. Calcutta, 2006.
4. Elliott, W.H. and Elliott, D.C., Biochemistry and Molecular Biology, Oxford University Press, Oxford. 2001.
5. Harper's Biochemistry by Murray R.K., Granner D.K., Mays P.A., Rodwell V.W., McGraw Hill Publication, 2000.
6. Horton, H.R., Morsan, L.A., Scrimgeour, K.G., Perry, M.D., Rawn, J.D., Principles of Biochemistry, Pearson Education, International, 2006.
7. Mathews, C.K., Van Holde, K.E., Ahern, K.G., Biochemistry, Pearson Education Pvt. Ltd., Delhi, India, 2003.
8. McKee, T., McKee J.R., Biochemistry (The Molecular Basis of Life) McGraw Hill Company, Inc.
9. Nelson D.L. and Cox M.M. Lehninger Principles of Biochemistry, MacMillan/Worth Publishers, 2001.
10. Stryer L. Biochemistry. W.H. Freeman and Co. New York, 2001.
11. Voet D. Voet J.G. and Pratt C.W. Fundamentals of Biochemistry, John Wiley and Sons Inc., New York, 1999.
12. Wilson K. and Walker J. Principles and Techniques of Practical Biochemistry Cambridge University Press, Cambridge, 1994.
13. Zubay G.L., Parson, V.W. and Vence D.E. Principles of Biochemistry. Wm.C. Brown Publishers, Oxford, England, 1995.


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PAPER VI: BIOSTATISTICS AND POPULATION GENETICS

Duration: 3 Hours

Max. Marks: 100

Periods : 80

Biostatistics

Unit I:

1. Definition Scope and applications of biostatistics
2. Collection, organization and representation of data (graphical- Bar, Histogram, Frequency polygon, line diagram & diagrammatic).
3. Basic statistics-Arithmetic mean, Harmonic mean, Geometric mean, Median, Mode, Mean deviation. (Direct, short-cut and step-deviation for all)

Unit II

1. Statistics of dispersion, Coefficient of variation.
2. Standard error; Confidence limits.
3. Probability distributions (Binomial, Poisson and Normal).
4. Testing of Hypothesis, level of significance; Type I and II errors.
5. Tests of statistical significance (Student's t-test, Z-test, Chi-square test).
6. Correlation and regression.
7. Analysis of Variance (One way and two way ANOVA)

Population Genetics

Unit III

1. Concepts of evolution and theories of organic evolution with an emphasis on Darwinism. 5
2. Neo-Darwinism 10
 - 2.1 Hardy-Weinberg's law of genetic equilibrium.
 - 2.2 Detailed account of destabilizing forces-
 - (i) Natural selection
 - (ii) Mutation
 - (iii) Genetic drift
 - (iv) Migration
 - (v) Meiotic drive
 - 2.3 Genetic structure of natural populations.
 - 2.4 Variations -including transgressive variations
 - 2.5 Models explaining changes in genetic structure of populations.
 - 2.6 Factors affecting human disease frequency.
3. Molecular population genetics 5

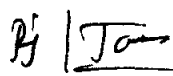
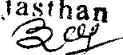
- 3.1 Patterns of change in nucleotide and amino acid sequences.
- 3.2 Ecological significance of molecular variations.
- 3.3 Emergence of Non-Darwinism-Neutral hypothesis.
- 4. Genetics of Quantitative traits in populations 10
 - 4.1 Analysis of quantitative traits.
 - 4.2 Quantitative traits and natural 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.

Unit IV

- 1. Genetics of speciations 10
 - 1.1 Phylogenetic and biological concept of species.
 - 1.2 Patterns and mechanisms of reproductive isolation.
 - 1.3 Modes of speciation (allopatric, sympatric, parapatric & peripatric).
- 2. Molecular Evolution 10
 - 2.1 Gene evolution.
 - 2.2 Evolution of gene families, molecular drive.
 - 2.3 Assessment of molecular drive.
 - 2.4 Micro-and macro-evolution.
- 3. Molecular phylogenetics 12
 - 3.1 Construction of phylogenetic trees.
 - 3.2 Phylogenetic inference-distance methods, parsimony methods, maximum likelihood method.
 - 3.3 Immunological techniques.
 - 3.4 Amino acid sequence and phylogeny.
 - 3.5 Nucleic acid phylogeny-DNA-DNA hybridizations, restriction enzyme sites, nucleotide sequence comparisons and homologies.
 - 3.6 Molecular clocks.

Recommended Books

- 1. Batschelet, E.; Introduction to Mathematics for Life Scientists Springer, Verlag, Berlin.
- 2. Dobzhansky, T., Alaya, F.J., Stebbins, G.L., Valentine, J.M., Genetics and Origin of Species, Surjeet Publication, Delhi.


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3. Futuyamma, D.J., Evolutionary Biology, Sinauer Associates, Inc., Massachusetts, U.S.A.
4. Green, R.H.: Sampling Design and Statistical Methods for Environmental Biologists, John Wiley & Sons, New York.
5. Hart, D.L., A Primer of Population Genetics, Sinauer Associates, Inc., Massachusetts, U.S.A.
6. Jha, A.P. Genes and Evolution, John Publication, New Delhi.
7. Jorgenson, S.E.: Fundamentals of Ecological Modeling, Elsevier Press, New York.
8. King, M., Species Evolution: The Role of Chromosomal Change, Cambridge University Press, Cambridge.
9. Lendern, D., Modelling in Behavioural Ecology, Chapman and Hall, London, U.K.
10. Merral, D.J., Holt, R. Evolution and Genetic, Richart and Winston, Inc.
11. Murray, J.D., Mathematical Biology, Springer-Verlag, Berlin.
12. Smith, J.M., Evolutionary Genetics, Oxford; University Press, New York.
13. Snedecor, H.W. and Cochran, W.G., Statistical Methods. Affiliated East-West Press, New Delhi.
14. Sokal, R.R. and Rolf, F.J.: Biometry; Freeman, San Francisco.
15. Strickberger, M.W., Evolution, Jones & Bartlett Publishers, Boston, London.
16. Swartzman, G.L. and Kaluzny, S.P.O.: Ecological Simulation Primer, MacMillan, New York.

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PRACTICAL EXERCISES

I. **Biosystematics and Taxonomy:**

1. Identification, Classification and study of the animals from major invertebrate group (Protozoa to Hemichordate including minor phyla) using museum specimens, microscopic slides, models or charts or photographs.

2. Problems based on Shannon weiner index, Dominance index. Estimation of population density of given sample by Mark recognition recapture method.
Determination of population density by quadrate method.

II **Anatomy:**

a. **Major:**

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

b. **Minor:**

5. C.S. of arm of Starfish.
6. General anatomy of Holothurians.
7. Aristotle's lantern of Sea urchin.

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

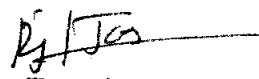

IV. **Study of Permanent Preparations (Protozoa to Hemichordata):**

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

Larva: Aurelia-planula, Redia, Cercaria, Metacercaria, Onchosphere, Cysticercus, Trochophore, Nauplius, Zöea, Mysis. Megalopa Phyllosoma, Veliger, Glochidium, Bipinnaria, Ophiopluteus, Echinopluteus, Auricularia, Tornaria.

V. **Biological Chemistry:**

- (i) Verification of Beer-Lambert's Law.
- (ii) Quantitative estimation of the following in various tissues:
 - a) Carbohydrates: Glycogen, glucose.
 - b) Proteins: Total proteins - Lowry *et al* method
 - c) Lipids: Phospholipids and cholesterol.


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- d) Nucleic acid: DNA and RNA.
- e) Enzymes: Acid and alkaline phosphatases.


VI. Physiology:

- (i) Study of the following with the help of Computer Assisted Learning (CAL) (please see E-pharm programme).
 - A. The effect of K^+ , Ca^{++} acetylcholine and epinephrine on the isolated heart of frog* and conclude your data with the graphic representation Computer Assisted Learning (CAL) be included.
 - B. The effect of various doses of acetylcholine and Nor-epinephrine on blood pressure, heart rate and respiratory rate of the rabbit.
 - C. The effects of Atropine, Epinephrine, Ephedrine and Eserine on Rabbit's eyes. Other such exercises can be framed from the E-Pharm software.
- (ii) Determination of blood pressure, pulse rate, heart beat and respiration rate.
- (iii) Photometric determination of hemoglobin in blood sample.
- (iv) Determine of MCV, MCH, MCHC and colour index of the given sample of blood.
- (v) Demonstration of the following in blood: Clotting time, erythrocyte sedimentation rate, haemolysis and crenation.
- (vi) Determination of the urea in urine/blood.
- (vii) Determination of the glucose in urine.
- (viii) Tests of digestive enzymes in different parts of the alimentary canal.

Note : * indicates use of Computer soft wares.

VII. Cell & Molecular Biology & Biotechnology:

- (i) Squash and smear preparations of testis of cockroach and grasshopper using aceto-orcein, Fielgen and Giemsa stains.
- (ii) Study of mitosis in onion root tip.
- (iii) Study of giant chromosomes in the salivary gland of Chironomus or Drosophila larva.
- (iv) Vital and supravital staining (with Neutral Red and Janus Green B) of cells of the testis of any insect or mammal to study the mitochondria.
- (v) Chromosome study in cells of the testis of an insect / mammal / cells of the bone marrow of a mammal.
- (vi) Paper chromatography: Unidimensional chromatography, using amino acids from purified samples and biological materials (Ascending and Descending).
- (vii) Electrophoresis: Paper/Horizontal/Vertical -Proteins/DNA/RNA.
- (viii) Study of prepared microscopic slides, including those showing various cell types, mitosis, meiosis and giant chromosomes.


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Note: It is compulsory to submit prepared slides from each exercise for examination.

VIII. Population Genetics:

- (i) Numerical problem based on Hardy Weimberg's law, calculation of allelic frequencies, inbreeding genotypic frequencies and estimation of heritability,
- (ii) Problems based on syllabus.

IX. Biostatistics:

- (i) Preparation of frequency tables and graphs/line diagrams/bardiagrams/histogram/Pie charts.
- (ii) Exercises on Arithmetic mean, Harmonic mean Geometric mean, Median, Mode (Direct, short- cut and step -deviation).
- (iii) Calculation of standard deviation, variance and standard error of mean.
- (iv) Calculation of probability and significance between means using Students t-test and Chi-square test.
- (v) Plotting the slope of a line on a graph; calculations of the slope of a line, coefficient correlation and regression.

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PRACTICALS

Scheme of Practical Examination

Total Marks-200

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

I Day (I, II & III Papers)

Time: 5 hrs.

Max Marks: 100 Marks

1. Biosystematics & Taxonomy	10
2. Anatomy	
a. Major	16
b. Minor	8
3. Cell & Molecular Biology and Biotechnology	12
4. Spotting No. 1 – 8	24
5. Record	10
6. Viva-voce	10

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7. Seminar & Submission of slides/ Tour Report	5+5
	Total = 100

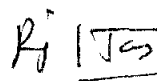
II Day (IV, V & VI Papers)

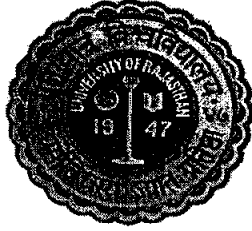
Time: 5 hrs.

Max Marks: 100	Marks
1. Gen. Physiology	20
2. Biochemistry	20
3. Biostatistics	10
4. Population Genetics	5
5. Spotting (1 to 5)	15
6. Record	10
7. Viva-voce	10
8. Seminar	10
	Total = 100

Note:

1. With reference to anatomy (dissection, black papering and labelling) and type study candidates must be well versed in the study of various systems.
2. With reference to permanent preparations and microscopic slides, the exercise may be substituted with diagrams/photographs/models/charts etc.
3. Candidates must keep a record of all work done in the practical class and submit the same for inspection at the time of the practical examination.
4. The candidates may be asked to write detailed methodology wherever necessary and separate marks may be allocated for the same.
5. Mounting material for permanent preparations would be as per the syllabus as well as available through collection and culture methods.
6. It should be ensured that animals used in the practical exercise are not covered under the Wildlife Act 1972 and amendments made subsequently.
7. There are unlimited amounts of alternative practicals that can be carried out using observational and other works in the field. Field work also may be encouraged for the students to recognize their social and environmental responsibility. Non-invasive and non-harmful practical exercises for the study of anatomy, Physiology, Ethology, Epidemiology and Ecology may be designed.


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SYLLABUS

M.Sc.

ZOOLOGY

(ANNUAL SCHEME)

M.Sc. (Final) Examination 2023-2024

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UNIVERSITY OF RAJASTHAN
UGC CURRICULUM FOR POSTGRADUATES

M.Sc. Zoology Final (Annual Scheme)

3 Hours Duration		100 Marks
Paper I	Biology of Chordates	(each paper)
Paper II	Environmental Biology and Ethology	
Paper III	Genes and Differentiation	
Paper IV	Tools and techniques in Biology	
Paper V	Special Paper	
Paper VI	Special Paper	
	Laboratory Exercises	
	Demonstration and Tutorials	

SEMINAR

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 10 very short answer question of 2 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: BIOLOGY OF CHORDATES

Duration: 3 Hours

Max. Marks – 100

Periods: 70

1. Origin and outline classification of the chordates. 3
2. Interrelationships of Hemichordata, Urochordata and Cephalochordata and their relations with other deuterostomes. 5
3. Life histories of sessile and pelagic tunicates, *Ascidia*, *Herdmania*, *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. (20)

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2. Andrevos, S.M., Miles, R.S., Walker, A.D. : Problems in Vertebrate Evolution, academic Press, New York.
3. Andrew, S.M. : Problems in. Vertebrate Evolution, Academic Press, New York.
4. Barbiur T. Hongton : Reptiles and Amphibians : Their Habitats and Adaptations, Miffin Co, New York.
5. Barrington, E.J.W. ; The Biology of Hemichordata and Protochordata, Olter and Boyd, Edinbrough.
6. Bourne, G.H. : The Structure Functions of Nervous Tissues Academic Press; New York.
7. Carter, G.S.: Structure and Habit in Vertebrate Evolution Sedwick and Jackron, London.
8. Clark, W.K., History of Primates, University of Chicago Press, Chicago.
9. Colbert, E.H. : Evolution of the Vertebrates, John Wiley & Sons, Inc., New York.
10. DeVeer, S.G. : Embryos and Ancestors, Claredon Press, Oxford.
11. Eccles, J.C.: The uncerstanding of the Brain, McGraw Hill Company, New York.
12. Joysey, K.A. and Kemp, T.S. : Evolution, Oliver and Boyd, Edinbrough.
13. Kent, C.G. Comparative Anatomy of Vertebrates.
14. Kingsley, J.S.: Outlines of Comparative Anatomy of Vertebrates Central Book Depot, Allahabad.
15. Lovtrup, S. : The Phylogeny of Vertibrate, John Wiley &. Sons, London.
16. Malcom Jollie: Chordata Morphology, East-West Press Pvt. Ltd., New Delhi.
17. Messers H.M An Intraductin of Vertebrate Anatomy.
18. Milton, H. : Analysis of Vertebrate Structure, John Wiley and Sons Inc., New York.
19. Monielli, A.R.: The chordates, Cambridge University Press, London.
20. Montagna, W. : Comparative Anatomy, John Wiley & Sons, Inc., New York.
21. Romer, A.S. : Vertebrate Body, W.B. Saunders Company, Philadelphia.
22. Romer, A.S. : Vertebrate Palentology, University of Chicago Press, Chicago.
23. Sedgwick, A.A.: Text Book of Zoology, Vol.-II.
24. Smith, H.S.: Evolution of Chordata Structure, Hold Rinehart and Winstoin, Inc., New York.
25. Tansley, K.: Vision in Vertebrate, Chapman and Hall Ltd., London.
26. Torrey, T.W.: Morphogenesis of Vertebrates, John Wiley & Sons, New York.
27. Walters, H.E. and Sayles, L.D.: Biology of Vertebrates, Macmillan and Co., New York.
28. Waterman, A.J. : Chordata Structure and Function, MacMillan Co., New York.

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R. J. Tan

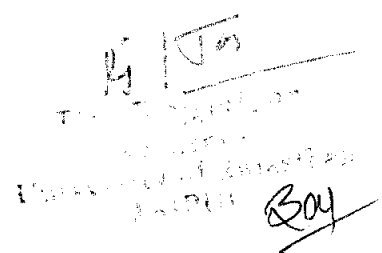
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Day

- 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.

Recommended Books

1. Alexander, R.M. : The chordata, Cambridge University Press, London.



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 BOY

29. Weichert, C.K. and Presch, W. Elements of Cordate Anatomy, MacGraw Hill Book Company, New York.
30. Young J.Z. : Life of Vertebrates, The Oxford University Press, London.

M.Sc. FINAL (ZOOLOGY)

PAPER II : ENVIRONMENTAL BIOLOGY AND ETHOLOGY

Duration : 3 Hours

Max. Marks – 100

Periods : 70

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: Conservation 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 estuarine areas with respect to | |
| 6.2.1 | Extent | |
| 6.2.2 | Zonation | |

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- 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 Ethology

- 1.1 Branches and significance of Ethology: Ethophysiology, Ethoendocrinology, Neuroethology, Human ethology, Behavioural genetics, sociobiology.
- 1.2 Milestones of Ethology: Konrad Lorenz, Niko Tinbergen, Karl Von Frisch, BF Skinner, HF Harlow.
- 1.3 Proximate and ultimate mechanisms of ethology.

2. Concepts of Ethology:

- 2.1 Motivation and Innate behaviour (Fixed action pattern).
- 2.2 Sign stimulus, super normal stimulus.
- 2.3 Action specific energy and Innate releasing mechanism.
- 2.4 Difference between learned and Innate behaviours.

3. Nervous system and Behaviour

- 3.1 Mammalian brain structure and behaviour.
- 3.2 Hypothalamus and Innate behaviour.
- 3.3 Behavioural endocrinology including effect of drugs.
- 3.4 Orientation - taxis and kinesis, bird migration and navigation
- 3.5 Biological clocks, Chronobiology.

4. Learning and Imprinting

- 4.1 Introduction and definitions.
- 4.2 Habituation; Conditioning.
- 4.3 Trial and error; Imprinting.

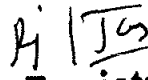

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- 4.4 Neural mechanism of learning .
- 4.5 Birds song learning behavior in the context of Tinbergen's 4 aims.
- 5. **Sociobiology**
 - 5.1 Introduction- definition, WO Wilson, Richard Dawkins, WD Hamilton.
 - 5.2 Units of sociobiology,
 - 5.3 Hamilton's theory and Altruism, cooperation, reciprocation and Eusociality,
 - 5.4 Properties, advantages of a social group, Social organisation in primates.
- 6. **Social Behaviour**
 - 6.1 Parental care- Types , Parent offspring conflict.
 - 6.2 Courtship and mating.
 - 6.3 Aggression and territory
 - 6.4 Evolution of social systems.
- 7. **Communication in animals**
 - 7.1 Auditory, Echolocation, Infra- and ultra- sounds.
 - 7.2 Tactile, Visual ,
 - 7.3 Pheromones- vertebrates and invertebrates
 - 7.4 Language of honey bees-circle and waggle dance.
- 8. **Human Behaviour-**
 - 8.1 Desmond Morris, Sarah Hrdy.
 - 8.2 Sign stimulus, Imprinting.
 - 8.3 Kinship , Aggression.
 - 8.4 Pheromones.

Recommended Books (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 Col, New York.
4. Iorgenson, S.E.: Fundamentals of Ecological Modeling, Elsevier.
5. Krebs, C.J.: Ecological Methodology, Harper and Row, New York.

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6. Krebs, C.J.: Ecology, Harper and Row, New York.
7. Ludwig, J. A. and Reynolds, J.F.: Statistiaal 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

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

PAPER III: GENES AND DIFFERENTIATION

Duration : 3 Hours



Max. Marks – 100

Periods : 70

- | | | |
|----|--|---|
| 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 disruptions.	
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	Ovarian development.	
10.4	Secondary sex determination in mammals.	
10.5	Environmental sex determination.	
11.	Cell diversification in early embryo	6
11.1	<i>Xenopus</i> blastomeres.	
11.2	Morphogen gradients.	
11.3	Totipotency & Pleuripotency.	
11.4	Embryonic stem cells.	
11.5	Renewal by stem cells-epiderms.	
11.6	Skeletal muscle regeneration.	
11.7	Connective tissue cell family.	
12.	Hemopoietic stem cells	6

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- 12.1 Stern cell disorders.
- 12.2 Blood cell formation.
- 12.3 Bone marrow transplants.
- 12.4 Gene therapy.

Recommended Books

- 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

Duration : 3 Hours

Max. Marks – 100

Periods : 70

Section A : Tools


- 1. Principles and application of 10
 - 1.1 Light Microscopy and micrometry.
 - 1.2 Phase contrast microscopy.
 - 1.3 Interference microscopy.
 - 1.4 Polarized microscopy.
 - 1.5 Fluorescence & epifluorescence microscopy.
 - 1.6 Transmission electron microscopy.
 - 1.7 Scanning electron microscopy.
 - 1.8 Confocal scanning and deconvolution microscopy.
 - 1.9 Atomic Force 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, agarose, PAGE, submerged DNA electrophoresis, Pulse Chase electrophoresis, iso-electrofocussing 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 etch.
 - 2.5 X-Diffraction.
 - 2.6 Lambert-Beers Law and colorimeter & spectrophotometer -fluorescence, U.V., N.M.R., O.R.D./CD, ESR, IR, Atomic absorption and plasma emission.
 - 2.7 Flow cytometer / Fluorescence activated cell sorter.
- 3. Principles and application of radiation techniques in Biology 10
 - 3.1 Radiation dosimetry.
 - 3.2 Radioisotopes and half life of isotopes.

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- 3.3 Tracer techniques in biology.
- 3.4 Cerenkov radiation.
- 3.5 Liquid scintillation counter.
- 3.6 G.M. Counter
- 3.7 Autoradiography.

Section B : Techniques

1.	Assay	2
	1.1 Definition and criteria of reliability.	
	1.2 Chemical assays.	
	1.3 Biological assays <i>in vivo</i> and <i>in vitro</i> 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, alcohol 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.	
5.	Cell Culture techniques	4


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- 5.1 Design and functioning of tissue culture laboratory.
- 5.2 Cell proliferation measurements.
- 5.3 Cell viability testing.
- 5.4 Culture media preparation and cell harvesting methods.
- 6. Cryotechniques 3
 - 6.1 Cryopreservations for microscopy.
 - 6.2 Cryotechniques for microscopy.

Recommended Books

- 1. Johns, 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) Zoology General Papers

PRACTICALS

General Papers:

I. **Anatomy**

(a) **Major**

- (i) Cranial nerves of *Wallago attu*.
- (ii) Cervical nerves of Rat.
- (iii) Reproductive organs of Rat.

(b) **Minor**

- (i) Accessory respiratory organs of *Heteropneustes fossilis*.
- (ii) Labrinth organs of *Anabas testudens*.

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

Lower Chordates : Salpa: asexual and sexual stages, *Doliolum-oozoid*, *Botrylus*, *Herdmania*, *Amphioxus*.

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

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

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- Reptilia : *Testudo, Chelone, Sphenodon, Calotes, Hemidactylus, Phrynosoma, Draco, Varanus, Chameleon, Cobra, Hydrophis, Rattle snake, Viper, Pit, Viper, Krait, Eryx, Gavialis.*
- Aves : *Archaeopteryx. Tailor Bird, Indian Koel, Jungle fowl, Peacock, Columba, Parrot, Wood Pecker, Owl, Flamingo, Great Indian Bustard.*
- Mammals : *Ornithorhynchus, Echidna, Marcropus, Hedgehog, Manis, Loris, Bat, Mongoose, Hystrix, Otter.*

III. Study of Microscopic slides

- Lower Chordates : *Herdmania* spicules, *Herdmania* tadpole larva, *Amphioxus*- T.S. passing through oral hood, pharynx, testes and ovary, intestine and caudal regions. Ammocoeie larva (whole mount).
- Pisces : Placoid scale, cycloid scale, 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, lung, bone and spinal cords L.S./T.S. of pituitary gland, T. S. of simple cuboidal epithelium, simple columnar epithelium, simple squamous epithelium, adipose tissue and reticular tissues, Blood smear – identification of various cell types.



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

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

V. Tools and Techniques

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

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VI. Environment Biology

- (i) Analysis of pond / stagnant water for : pH, Acidity, Alkalinity, Dissolved oxygen, CO₂, Salinity, Phosphates, COD and BOD.
- (ii) Map (World/India/Rajasthan) to localize biodiversity, Major rivers, estuaries, oceans.
- (iii) Collection, isolation and identification of Planktons. (Phyto- and Zoo- planktons).

VII. Ethology

- (iv) Study of the food preference in Tribolium or any other grain/ pulse pest).
- (v) Study of communication in Earthworm by Pheromones .
- (vi) Effect of toxicants on movement of Fish .
- (vii) Study Learning by Trial and Error in Rat using Hebb- William Maze .
- (viii) Imprinting study using Chick.
- (ix) Listing of all the animals and recording of behaviour in Zoo/ Sanctuary/National Park.

VIII Development Biology

- (i) Frog : Egg, Cleavage (2-, 4-, & 8-celled), Morula, Blastula (including Yolk Plug stage) and neurula stages (Slides as well as preserved materials)
- (ii) Chick: 16 hrs, 21 hrs, 24 hrs, 28 hrs, 33 hrs, 38 hrs, 48 hrs, 70 hrs and 96 hrs.
- (iii) Chick development: Appearance of eyes, hair, beak and limbs.
- (iv) Window making: To study development of chick and blastoderm mounting.

Notes:

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

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Scheme of Practical Examination

Duration: 5 hrs.

Max. Marks: 100

Exercise

Marks

1. Anatomy	
a. Major	12
b. Minor	8
2. Ethology	6
3. Environmental Biology	10
4. Tools and Techniques	10
5. Development Biology	10
6. Spotting (No. 1-8)	24
7. Record + Submission of slides	5+ 5
8. Viva-voce	10

Total = 100

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

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ENVIRONMENTAL BIOLOGY

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

Duration : 3 Hours

Max. Marks - 100

Periods : 90

1. Biomes
 - 1.1 A-Terrestrial Biomes
 - 1.1.1 Desert
 - 1.1.2 Grassland: Prairies & Plains
 - 1.1.3 Tundra
 - 1.1.4 A 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

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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 an 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* and *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
 - 8.2.3 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

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- 9.6 Belt transect estimate
- 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

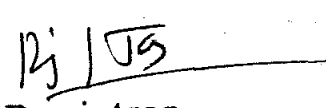

Duration : 3 Hours

Max. Marks – 100

Periods : 90

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
 - Natural sources of air pollution
 - Human caused air pollution
 - Acid rain
 - Climate: Topography and atmospheric process
 - Global warming: The green house effect, green house gases, potential effect of global warming
 - Control of air pollution
 - Ozone depletion
 - B. Water
 - Types and effects of water pollution

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- Infectious agents
 - O₂ 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

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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, forest wildlife sanctuaries of India and especially Rajasthan. (students are required to submit the joint report on the field visits 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.

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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 detector. (microbial).
6. Trips to natural habitat and manmade 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/sweage for physicochemical parameters including COD and BOD.
12. Field trip to ponds/coastal/other treatment (water or industrial water) plants. Report to be submitted.

Note:

1. Slides to be submitted from the exercises.
2. With reference of whole mounts and museum specimens the animal types may be substituted with diagrams/photographs/models etc.
3. It should be ensured that animals used in the practical exercise are not covered under the wild life act 1972 and amendments made subsequently.

PRACTICAL EXAMINATION SCHEME

Duration: 6 Hours

Max. Marks – 100

Exercise	Marks
1. Bioassay	5
2. TLC/ Paper chromatography: Pesticide/Toxicant residue analysis	10
3. Electrophoresis: Analysis of proteins	10
4. Bacterial examination of water (MPN index/IMVIC tests/Microbiological exercise agar plate technique)	10
5. Water/Waste water analysis for physicochemical properties	10
6. Identification of Zooplanktons	5
7. Determination of population density	5
8. Spotting (1-5)	15
9. Project/Seminar/Report	10
10. Record + submission of slides	5+5
11. Viva-voce	10

Total = 100

Recommended Books


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1. An Advanced Textbook on Biodiversity: Principles and practice. Krishnamurthy, K.V. 2004. Oxford and IBH. Publ. Co. New Delhi.
2. Climate change: past, present and future. Mathur, U. B. Geological Society of Bangalore 2010.
3. Coastal Ecosystem Processes. Alongi, D. M. 1998. CRC Press, New York.
4. Conservation Biology. Pullin, A.S. 2002. Cambridge University Press, UK.
5. Conservation Biology. Soule, M.E. 1986. (Ed.). Sinauer Associates, New York.
6. Ecological Census Techniques-A Handbook (2nd Edition). William J. Sutherland. Edited by William J. Sutherland.
7. Ecological Concepts. Cherrett, J. M. Blackwell Sci. Publications. Oxford U. K.
8. Ecological Methodology. IInd Edition Charles J. Krebs.
9. Ecological Methods. IVth Edition, Southwood, T. R. E., Dr. Peter A. Henderson. Wiley-Blackwell.
10. Ecology, Environment, and Resource Conservation. Singh, J. S., Singh, S. P. and Gupta, S. R. 2006. Anamaya Publ., New Delhi.
11. Ecology, Individuals, Populations and Communities. Begon, M., J.I., Harper and C. R. Townsend. Science. Oxford.
12. Ecology: Principles and Applications. Chapman, J.L. and Reiss, M.J. 2005. Cambridge University Press, London.
13. Ecology: The Experimental Analysis of Distribution and Abundance. (6th edn.). Krebs, C.J. 2008. Benjamin Cummings Publ., USA.
14. Edward J. Concepts of Ecology. (4 Ed.). Kormondy.
15. Elements of Ecology. (6th edn.). Smith, T.M. and Smith, R.L. 2006. Pearson. New Delhi.
16. Encyclopedia of Biodiversity. Levin, S. A. 2000. (Ed.). Academic Press.
17. Essentials of Conservation Biology. Primack, R.B. 1998. Sinauer Associates.
18. Essentials of Ecology and Environmental Science. Rana, S.V.S. 2005. Prentice Hall of India, New Delhi.
19. Freshwater Ecology: Principles and Applications. Michael Jeffries and Derek Mills. John Wiley.
20. Fundamentals of ecological modeling. Jorgensen, S. E., & Bendricchio, G. (Vol. 21). Elsevier.
21. Fundamentals of Ecology. Odum E.P. and Barrett, G. W. (2005). Thomson Asia Pvt. Ltd. Syngapore.
22. Land Mosaics: The Ecology of Landscapes and Regions. Forman, R.T. 1995. Cambridge Univ. Press, Cambridge, UK.
23. Landscape Ecology. Forman, R.T.T. and Godron, M. 1986. John Wiley & Sons, New York.
24. Population Biology. Elseth. B. D. and K. M. Baumgartner. Van Nostrand Co., New York.
25. The Atmosphere. Lutgens, F.K. and Tarbuek, J.E. 1992. Prentice Hall, New Jersey
26. The Living Landscape: An Ecological Approach to Landscape Planning, 2nd Edition. Steiner, F. 1999. McGraw Hill, Inc., New York.

7. FISH BIOLOGY

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