



पाठ्यक्रम SYLLABUS

SCHEME OF EXAMINATION AND COURSES OF STUDY

FACULTY OF SCIENCE

M.Sc. Zoology (Previous) & (Final)

2009-10 से प्रभावी(w.e.f.)

सत्र 2013-14

महर्षि दयानन्द सरस्वती विश्वविद्यालय, अजमेर

NOTICE

1. Change in Statutes/Ordinances/Rules/Regulations/ Syllabus and Books may, from time to time, be made by amendment or remaking, and a candidate shall, except in so far as the University determines otherwise comply with any change that applies to years he has not completed at the time of change. **The decision taken by the Academic Council shall be final.**

सूचना

1. समय-समय पर संशोधन या पुनः निर्माण कर परिनियमों / अध्यादेशों / नियमों / विनियमों / पाठ्यक्रमों व पुस्तकों में परिवर्तन किया जा सकता है, तथा किसी भी परिवर्तन को छात्र को मानना होगा बशर्ते कि विश्वविद्यालय ने अन्यथा प्रकार से उनको छूट न दी हो और छात्र ने उस परिवर्तन के पूर्व वर्ष पाठ्यक्रम को पूरा न किया हो। **विद्या परिषद द्वारा लिये गये निर्णय अन्तिम होंगे।**

M.Sc. ZOOLOGY**SCHEME OF EXAMINATION**

1. The number of papers and the maximum marks for each paper, practical shall be shown in the syllabus for the subject concerned. It will be necessary for a candidate to pass in the theory part as well as in the practical part (wherever prescribed) of a Subject/Paper separately.
2. A candidate for a pass at each of the Previous and the Final Examination 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 in the examination, provided that if a candidate fails to secure at least 25% marks in each individual paper work, wherever prescribed, he shall be deemed to have failed at the examination not with standing 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
Second Division	48%	

All the rest will be declared to have passed the examinations.
3. If a candidate clears any paper(s) Practical(s) / Dissertation Prescribed at the previous and or/ final examination 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 year, provided that in case where a candidate require more than 25% marks in order to reach the minimum aggregate as many marks out of those actually secured by him will be taken into account as would enable him to make the deficiency in the requisite minimum aggregate.
4. Only such candidates shall be permitted to offer dissertation/ Fields 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 scheme, irrespective of the no. of papers in which a candidate actually appeared at the examination.
5. The Thesis/Dissertation/Survey Report/ Field Work shall be typed & written and submitted in triplicate to the Principal of the College concerned or the Head of Department concerned, as the case may be at least seven days before the commencement of the theory examination.

1. Introduction to the science of taxonomy; rules of nomenclature.
2. Principles of classification : theories of biological classification & their history; the species category; the polytypic species; population systematics, intraspecific categories.
3. Methods of classification : taxonomic collection & the processes of identification, taxonomic characters; types of variations (qualitative and quantitative) within a single population, methods of arriving at taxonomic decisions on species level; preparation and use of taxonomic keys.
4. Trends in biosystematics - concepts of different conventional and newer aspects

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- (a) Chemotaxonomy
- (b) Cytotaxonomy
- (c) Molecular taxonomy
- (d) Elementary idea about sound based identification and classification.
5. Molecular perspective on the conservation of diversity. Diversity and ecosystem process: theory; achievements and future directions.
6. Evaluation of bio diversity indices.
 - (a) Shannon – Weininger index, dominance index.
 - (b) Similarity and dissimilarity index.
 - (c) Association index
7. Basics of GIS (Geographical Information System) and its application in documentation and presentation of invertebrate faunal diversity

Section – B**Structure and function of Invertebrates :**

1. A study of the classification of Invertebrates, with distinguishing features & examples of various subdivisions.
2. Locomotory mechanisms:
 - (a) Amoeboid movements: ultrastructure of cilia and flagella; ciliary and flagellar movements; molecular and physiological mechanisms involved in the three kinds of movements.
 - (b) Myonemes and muscle fibres in invertebrate structure and their involvement in locomotion action.
 - (c) Locomotion in relation to hydrostatics, coelom, metamerism, arthropodization.
 - (d) An outline of flight mechanism in insects.
3. Feeding mechanisms:
 - (a) Amoeboid feeding.
 - (b) Ciliary feeding.
 - (c) Filter feeding.
 - (d) Parasitic mode of feeding.
 - (e) Feeding mechanisms in insects and echinoderms.
4. Respiration:
 - (a) Respiration in lower invertebrates (Protozoans to Helminthes):
 - (b) Gills and Lophophores.
 - (c) Gills and lungs in Mollusca.
 - (d) Gills, trachea and lung like structures in Arthropods.
 - (e) Physiology of respiratory pigments in invertebrates.
6. Excretion: a study of structural and functional organization of excretory systems in various invertebrate groups and a survey of various excretory products met within them.
7. Osmoregulation and ionic regulation : a survey of principal mechanisms in fresh water, marine and terrestrial forms.

8. Structural and functional organization of nervous systems and receptors:
 - (a) Plan of nervous systems in the Coelenterates, Platyhelminths, Annelids, Arthropods, Molluscs and Echinoderms; structural and functional complexities of brain and ganglionic structures.
 - (b) Receptors: Structural and functional organization of the mechanoreceptors, chemoreceptors and photoreceptors.
9. Endocrine system : a survey of endocrinal structures and their hormones; role of neurosecretions and hormones in developmental events of insects and crustaceans.
10. Reproduction :
 - (a) Reproduction in Protozoa
 - (b) Reproduction in Porifera
 - (c) Reproduction in Metazoa : Sexual reproduction; Parthenogenesis.
 - (d) Reproduction in Metazoa : Asexual reproduction in Coelenterata and Polychaeta.
 - (e) Larval forms and their significance.

Section – C**Origin and interrelationship between invertebrate phyla :**

1. Criteria for phylogenetic interrelationships between Invertebrate phyla.
2. Origin of Parazoa, Mesozoa and Metazoa.
3. Origin of Radiata (Coelenterata and Ctenophora).
4. Origin of Bilateria from Radiata (Importance of Planula larva and Ctenophores).
5. Phylogenetic significance of Rhynchocoela.
6. Interrelationship of the Pseudocoelomate groups, with special reference to Rotifera, Gastrotricha, Kinorhynca, Nematomorpha and Entoprocta.
7. Affinities and evolutionary significance of the unsegmented lesser protostome phyla (Periapulida, Echinrodea and Sipunculoidea, Echiurida and Sipunculoidea).
8. Phylogenetic relationship between the coelomate phyla (Annelida, Onychophora, Arthropoda, Mollusca).
9. Affinities and evolutionary significance of the Lophophorate coelomate phyla (Brachiopoda, Phoronida and Ectoprocta).
10. Affinities of the invertebrate deuterostome phyla (Chactognatha, Echinodermata, Pogonophora and Hemichordata).

Suggested Reading Material (All latest editions)

1. E.J.W. Barrington Invertebrate Structure and Function, ELBS.
2. M. Kato. The Biology of Biodiversity, Springer.
3. J.C. Avise. Molecular Markers, Natural History and Evolution, Chapman & Hall, New York.
4. E.O. Wilson. Biodiversity, Academic Press, Washington.
5. G. G. Simpson Principle of animal taxonomy; Oxford IBH Publishing

- Company.
6. E. Mayer. Elements of Taxonomy.
 7. E.O. Wilson. The Diversity of Life (The College Edition), W.W. Northern & Co.
 8. B.K. Tikadar. Threatened Animals of India, ZSI Publication, Calcutta

Paper II : Biological Chemistry and General Physiology

Section – A

Biological Chemistry :

1. Basic chemical concepts : A study of the chemical bonds and functional groups.
2. Biocatalysis : Classification and nomenclature of the enzymes; nature of enzymes, enzyme specificity; factors affecting enzyme activity; enzymatic and non-enzymatic catalysis; coenzymes and their functions.
3. Energy considerations : Biological oxidation & reduction. Fundamental reactions of biological oxidation; redox potential and electron transfer system enzymes and prosthetic groups.
4. Organic constituents in living systems.

I. Carbohydrates

A. Definition, general properties, classification; configuration of carbohydrates:

B. Structure and importance of :

(a) Monosaccharides :

Trioses	:	Glyceraldehyde; dihydroxyacetone.
Tetroses	:	Erythrose; erythrulose.
Pentoses	:	Ribose; (Ribulose); Xylulose.
Hexoses	:	Glucose, Fructose, Galactose
(b) Disaccharides	:	Lactose, maltose, sucrose.
(c) Polysaccharides	:	Cellulose, starch, glycogen, pectin, chitin
mucopolysaccharides.		

Sugar Derivatives :

(i) Deoxy Sugars	:	Deoxyribose.
(ii) Amino Sugars	:	Glucosamine; neuraminic acid
(iii) Sugar acids	:	Glyceric acid, uronic acids & galactouronic acids, ascorbic acid.
(iv) Sugar alcohols	:	Glycerol, mesoinositol.
(v) Phosphoric ester of sugars	:	Triose Phosphate, Pentose Phosphate. Hexose Phosphate.

C. Metabolism :

- (a) Catabolism of glycogen, glucose & fructose, details of glycolysis & Krebs cycle; Cori cycle.
- (b) Phosphogluconate pathways (Pentose Phosphate Pathway).

(c) Synthesis of glycogen: glycogenesis and glycogenolysis.

II. Proteins :

- (a) Definition, general properties: classification and importance of amino acids & proteins; nucleoproteins.
- (b) Structural formulae of the amino-acids.
- (c) Structure of proteins: primary, secondary, tertiary and quaternary. Domain structure (Basic knowledge of the determination of amino-acid sequence as exemplified by a tripeptide).
- (d) **Metabolism :**
 - (i) Amino acid degradation : deamination reactions : oxidative and non oxidative deamination reaction: Trans-amination & transdeamination; decarboxylation; Ornithine cycle of urea formation; fate of carbon skeleton of the amino acids (metabolism of individual amino-acids excluded)
 - (ii) Synthesis of the non-essential amino-acids and protein.

Section – B

III. Lipids :

- (a) Definition, general properties & classification.
- (b) Fatty acids : Structure properties, types and importance, with special reference to essential fatty acids.
- (c) Structure and importance of :
 - (i) Simple lipids : fats, waxes.
 - (ii) Compound lipids : Phospholipids; glycolipids; aminolipids; sulpholipids.
 - (iii) Fat soluble vitamins A, D, E and K.
 - (iv) Steroids : Cholesterol; bile acids, steroid hormones.
 - (v) Lipoproteins

IV. Inborn errors of metabolism.

General Physiology :

V. Physiology of the nervous system :

- (a) Nerve impulse : Biophysics. Biochemistry and Molecular physiology of genesis, conduction and transmission across synaptic junctions.
- (b) Synapse physiology and integration of information; coding in the neural information processing. Neuro transmitters.
- (c) Reflex action : Various types of central peripheral reflexes in mammalian nervous systems.

VI. Physiology of the receptor system :

- (a) General mechanism involved in stimulus transduction at receptor sites.
- (b) Functional architecture and stimulus processing in retina, organ of Corti and olfactory epithelium.

VII. Stress physiology :

- (a) Basic concept of environmental stress and strain: concept of elastic and plastic stress resistance, stress avoidance and stress tolerance.

- (b) Adaptation, acclimation and acclimatization
- (c) Concept of homeostasis
- (d) Physiological response to oxygen deficient stress
- (e) Physiological response to body exercise
- (f) Meditation, Yoga and their effects.

VIII. Thermoregulation and cold tolerance :

- (a) Basic principles of metabolism
- (b) Heat balance and exchange
- (c) Endotherms vs Ectotherms
- (d) Counter-current heat exchangers
- (e) Torpor, hibernation and aestivation
- (f) Adaptations to very cold environments

Section – C

General Physiology :

1. Physiology of muscle tissue :

- (a) Morpho-functional architecture of the contractile apparatus in muscle tissue.
- (b) A detailed study of the biophysical and biochemical events underlying contraction & relaxation process.
- (c) Physiological properties of cardiac, skeletal and visceral muscles.
- (d) Nerve innervation, denervation and muscle function.

2. Excretion :

Biophysics, architecture, biochemistry and physiology of various functions performed by the vertebrate nephron; origin and formulation of nitrogenous excretory products; physiological relationship between habitat and excretion mechanisms. Role of kidney in osmoregulation.

3. Ionic and osmotic balance :

- (a) Osmoregulation vs. osmoconforming
- (b) Osmoregulation in aquatic and terrestrial environments
- (c) Kidney function and diversity
- (d) Other osmoregulatory organs
- (e) Nitrogenous waste excretion

4. Respiration :

- (a) Factors modifying oxygen consumption in animals.
- (b) Acclimatization to low oxygen tension; toxicity of high oxygen tension.
- (c) Chemistry of respiration, with particular reference to mammals.
- (d) Buffer systems of blood and the acid-base balance.

5. Nutrition, digestion and absorption :

- (a) Nutritive types in animal kingdom.
- (b) Role of vitamins and minerals in nutrition. Deficiency diseases.
- (c) Composition, molecular mechanism of secretion & action of all types of digestive juices met within the mammalian digestive pathway;

hormonal and nervous regulation of secretion of digestive juices.

- (d) Physiological mechanisms involved in the absorption of the end products of digestion.

6. Blood and circulation of body fluids :

- (a) Physiology of RBC and the mechanism of transport of gases of blood; physiology of leukocyte function; antibody production, Anti-inflammatory activities, phagocytosis, physiological basis and clinical significance of blood groups; biochemistry and physiology of blood clotting.
- (b) Types of heart and transport mechanisms.
- (c) General comparative study of cardiac cycle in animals with particular reference to man.
- (d) Homeostasis and nervous regulation of heart function in vertebrates; conductile and contractile mechanisms in the heart.

7. Endocrine Physiology :

Cellular mechanisms of hormone action in target tissues; hypothalamic control of pituitary activity and phenomenon of neurosecretion; genesis, types and general functions of hormones of various endocrine glands (hypophysis, adrenal, thyroid, parathyroid, testis and ovary, Islets of Langerhans).

8. Reproduction :

Physiological events accompanying fertilization process, Endocrinological control of the testicular, ovarian and uterine functions, capacitation, physiological aspects of implantation and parturition.

Suggested Reading Material

1. Eckert, R. Animal Physiology : Mechanisms and Adaptation. W.H. Freeman and Company, New York.
2. Hochachka, P.W. and Somero, G.N. Biochemical Adaptation. Princeton, New Jersey.
3. Hoar, W.S. General and Comparative Animal Physiology, Prentice Hall of Indian.
4. Schiemdt Nielsen. Animal Physiology : Adaptation and Environment. Cambridge.
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. Wilson K. and Walker, J. Practical Biochemistry.
8. Willmer, P.G. Stone, and I. Johnston. Environmental Physiology. Blackwell Sci. Oxford, UK, 644pp.
9. Newell, R.C. (ed.) 1976. Adaptation to Environment. Essays on the physiology of marine animals. Butterworths, London, UK, 539pp.

10. Townsend, C.R. and P. Calow. *Physiological Ecology : An evolutionary approach to resource use*. Blackwell Sci. Publ., Oxford, UK.
11. Alexander, R.M.N. *Optima for animals*. Princeton Univ. Press, Princeton, NJ.
12. Dejours, P., L. Bolis, C.R. Taylor and E.R. Weibel (eds.), *Comparative Physiology : Life in water and on land*. Liviana Press, Padova, Italy.
13. Johnston, I.A., & A.F. Bennett (eds.). *Animals and Temperature: Phenotypic and Evolutionary Adaptation*. Cambridge Univ. Press, Cambridge, UK.
14. Louw, G.N. *Physiological Animal Ecology*. Longman Harloss, UK.
15. E.J.W. Barrington. *General and Comparative Endocrinology*, Oxford, Clarendon Press.
16. P.J. Bentley. *Comparative Vertebrate Endocrinology*. Cambridge University Press.
17. R.H. Williams. *Text Book of Endocrinology*, W.B. Saunders.
18. C.R. Martin. *Endocrine Physiology*. Oxford Univ. Press.
19. A Gorbman et al. *Comparative Endocrinology*, John Wiley & Sons.

Paper III : Molecular Biology, Biotechnology and Techniques in Biology**Section – A****Molecular Biology :**

1. Nucleic Acids : General account.
2. **DNA replication**
 - (a) Prokaryotic and eukaryotic DNA replication.
 - (b) Mechanics of DNA replication.
 - (c) Enzymes and accessory proteins involved in DNA replication.
3. **Transcription**
 - (a) Prokaryotic transcription.
 - (b) Eukaryotic transcription.
 - (c) RNA polymerases.
 - (d) General and specific transcription factors.
 - (e) Regulatory elements and mechanisms of transcription regulation.
 - (f) Transcriptional and post-transcriptional gene
3. **Post-transcriptional modifications in RNA**
 - (a) 5'-Cap formation
 - (b) Transcription termination
 - (c) 3'-end processing and polyadenylation
 - (d) Splicing, Editing
 - (e) Nuclear export of mRNA
 - (f) mRNA stability
4. **Translation**
 - (a) Genetic code
 - (b) Prokaryotic and eukaryotic translation

- (c) The translational machinery
- (d) Mechanisms of initiation, elongation and termination
- (e) Regulation of translation
- (f) Co-and post-translational modifications of proteins

Section – B**Biotechnology :**

1. Recombination and repair
 - (a) Holiday junction, gene targeting, gene disruption
 - (b) FLP/FRT and Crelox recombination
 - (c) RecA and other recombinases
 - (d) DNA repair mechanisms
2. Molecular mapping of genome and elementary knowledge of Bioinformatics
 - (a) Genetic and physical maps
 - (b) Physical mapping and map-based cloning
 - (c) Southern and fluorescence insituhybridization for genome analysis
 - (d) Molecular markers in genome analysis : RFLP, RAPD and AFLP analysis
 - (e) Application of RFLP in forensic, disease prognosis, genetic counseling pedigree and varietal analysis, animal trafficking and poaching; germplasm maintenance and taxonomy.
 - (f) DNA sequencing, sequencing methods, sequence submission, sequence alignment, sequence alignment tools, sequence homologies, DNA fingerprinting.
3. Transgenic animals and knock-outs
 - (a) Production
 - (b) Applications
 - (c) Embryonic stem cells
 - (d) Care and breeding of experimental animals including bioethics
4. Assisted reproduction technologies
 - (a) Embryo sexing and cloning
 - (b) Screening for genetic disorders
 - (c) ICSI, GIFT
 - (d) Cloning of animals by nuclear transfer
5. Assay
 - (a) Definition and criteria of reliability
 - (b) Chemical assays
 - (c) Biological assays-*in vivo* and *in vitro* assays
6. Principles and uses of analytical instruments-Balances, pH meter, colorimeter, spectrophotometer, flame photometer, ultracentrifuge, densitometric scanner, spectrofluorometer, chemiluminometers, radioactivity counters, differential scanning calorimeter. ESR and NMR spectrometers.

7. Microscopy – Principle of light transmission scanning, electron, phase-contrast.
Fluorescence, electron cryo and confocal, scanning electron microscopes.
Microphotography. Image analysers and their applications

Section – C

Techniques in Biology :

1. Microbiological techniques
 - (a) Media preparation and sterilization
 - (b) Inoculation and growth monitoring
 - (c) Use of fermentors
 - (d) Biochemical mutants and their use
 - (e) Microbial assays
2. Cell culture techniques
 - (a) Design and functioning of tissue culture laboratory.
 - (b) Cell proliferation measurements
 - (c) Cell viability testing
 - (d) Culture media preparation and cell harvesting methods
3. Cryotechniques
 - (a) Cryopreservation for microscopy
 - (b) Cryotechniques for microscopy
 - (c) Freeze-drying for physiologically active substances
4. Separation techniques in biology
 - (a) Molecular separations by chromatography, electrophoresis, precipitation etc.
 - (b) Organelle separation by centrifugation etc.
 - (c) Cell separation by flowcytometry, density gradient centrifugation, unit gravity centrifugation, affinity adsorption, anchorage based techniques etc.
5. Principles and techniques of nucleic acid hybridization and Cot curves; Sequencing of proteins and nucleic acids; Southern, Northern and South-Western blotting techniques; Polymerase chain reaction, Methods for measuring nucleic acid and protein interactions.
6. Principles and applications of tracer techniques in biology; Radiation dosimetry; Radioactive isotopes and half life of isotopes; Effect of radiation on biological system; Autoradiography; Cerenkov radiation; Liquid scintillation spectrometry.

Suggested Reading Material

1. Molecular Biology of the Gene, J.D. Watson, N.H. Hopkins, J.W. Roberts. J.A. Steitz and A.M. Weiner. The Benjamin/Cummings Pub. Co., Inc., California.
2. Molecular Cell Biology, J. Darnell, H. Lodish and D. Baltimore Scientific American Books, Inc., USA.

4. Molecular Biology of the Cell, B. Alberts, D.D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson. Garland Publishing Inc., New York.
5. Gene VI, Benjamin Lewin, Oxford University Press, U.K.
6. Molecular Biology and Biotechnology, A comprehensive desk reference, R.A. Meyers (ED.), VCH Publishers, Inc., New York.
7. Molecular Cloning : A Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York.
8. Animal Cell Culture – A practical approach, Ed. John R.W. Masters, IRL Press.
9. Introduction to Instrumental analysis, Robert Braun, McGraw Hill International Editions.
10. A Biologists Guide to Principles and Techniques of Practical Biochemistry, K. Wilson & K.H. Goulding, ELBS Edu.

Paper IV – Quantitative Biology, Genetics and Evolution

Section – A

Quantitative Biology :

1. Computer applications in zoological studies
 - (a) Fundamentals of computers
 - (b) History and generations of computers
 - (c) Computer peripherals and architecture
 - (d) Elementary idea about operating system (Window versions) and MS Office
 - (e) Software used in Biomedical Sciences (Image analysis, sound analysis, system automation and GIS).
2. Statistics
 - (a) Principles and practice of statistical methods in biological research, samples and populations.
 - (b) Graphical and tabular presentation of data.
 - (c) Basic statistics-average.
 - (d) Statistics of dispersion, coefficient of variation.
 - (e) Standard error; Confidence limits.
 - (f) Probability distributions (binomial, Poisson and normal).
 - (g) Tests of statistical significance.
 - (h) Simple correlation and regression.
 - (i) Analysis of variance.

Section — B

Advanced Genetics :

1. Mutation and mutagenic agents:
 - (a) Classification of mutations, translocation, inversion, deletion, duplication, replication and gene mutation.
 - (b) Molecular Basis of mutation.

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- (c) Mutagenic agents.
- 2. Multiple alleles: ABO, Rh and MN types of blood groups & their genetics
- 3. Cytoplasmic inheritance and maternal effects:
- 4. Evolution of sex chromosomes.
- 5. Human heredity:
Important human characters & their inheritance; principles of eugenics, genetic counselling, genetic disorders (Turner's syndrome, Klinefelter's syndrome, Down's syndrome), sequencing human genome.
- 6. Bacterial genetics:
Bacterial mutation, conjugation & transduction. Lysogenic and lytic cycle in bacteriophage, Plasmid.
- 7. Regulation of gene expression in prokaryotes and eukaryotes (Operon concept), DNA finger printing.
- 8. Principles, methods and application of Genetic engineering, Recombinant DNA Technology; in situ hybridization.

Section – C**Evolution :**

- 1. Concepts of evolution and theories of organic evolution with an emphasis on Darwinism.
- 2. Neo-Darwinism
 - 2.1 Hardy-Weinberg law of genetic equilibrium
 - 2.2 A detailed account of destabilizing forces :-
 - (a) Natural selection
 - (b) Mutation
 - (c) Genetic drift
 - (d) Migration
 - (e) Meiotic drive
- 3. Quantifying genetic variability
 - (a) Genetic structure of natural populations
 - (b) Phenotypic variation
 - (c) Models explaining changes in genetic structure of populations
 - (d) Factors affecting human disease frequency
- 4. Molecular population genetics
 - (a) Patterns of change in nucleotide and amino acid sequences
 - (b) Ecological significance of molecular variations
 - (c) Emergence of Neo-Darwinism-Neutral hypothesis
- 5. Genetics of quantitative traits in populations
 - (a) Analysis of quantitative traits
 - (b) Quantitative traits and natural selection
 - (c) Estimation of heritability
 - (d) Genotype-environment interactions
 - (e) Inbreeding depression and heterosis

- (f) Molecular analysis of quantitative traits
- (g) Phenotypic plasticity
- 6. Genetics of speciation
 - (a) Phylogenetic and biological concept of species
 - (b) Patterns and mechanisms of reproductive isolation
 - (c) Models of speciation (Allopatric, sympatric, parapatric)
- 7. Molecular Evolution
 - (a) Gene Evolution
 - (b) Evolution of gene families, Molecular drive
 - (c) Assessment of molecular variation
- 8. Origin of higher categories
 - (a) Phylogenetic gradualism and punctuated equilibrium
 - (b) Major trends in the origin of higher categories
 - (c) Micro and Macro-evolution
- 9. Molecular phylogenetic
 - (a) How to construct phylogenetic trees ?
 - (b) Phylogenetic inference-Distance methods, parsimony methods, maximum likelihood method.
 - (c) Immunological techniques
 - (d) Amino acid sequences and phylogeny
 - (e) Nucleic acid phylogeny-DNA-DNA hybridizations, Restriction Enzyme sites, Nucleotide sequence comparisons and homologies
- (f) Molecular clocks

Suggested Reading Material

- 1. Dobzhansky, Th. Genetics and Origin of Species. Columbia University Press.
- 2. Dobzhansky, Th., F.J. Ayala, G.L. Stebbins and J.M. Valentine. Evolution. Surjeet Publication, Delhi.
- 3. Futuyama, D.J. Evolutionary Biology, Sinauer Associates, INC Publishers, Dunderland.
- 4. Hartl, D.L. A Primer of Population Genetics. Sinauer Associates, Inc, Massachusetts.
- 5. Jha, A.P. Genes and Evolution. John Publication, New Delhi.
- 6. King, M. Species Evolution-The role of chromosomal change. The Cambridge University Press, Cambridge.
- 7. Merrel, D.J. Evolution and Genetics Holt, Rinehart and Winston, Inc.
- 8. Smith, J.M. Evolutionary Genetics. Oxford University Press, New York.
- 9. Strikberger, M.W. Evolution. Jones and Bartlett Publishers, Boston London.
- 10. Batschelet, E. Introduction to mathematics for life scientists. Springer-Verlag, Berlin.
- 11. Jorgensen, S.E. Fundamentals of ecological modeling. Elsevier, New York.

12. Swartzman, G.L., and S.P.O. Kaluzny. Ecological simulation primer. Macmillan, New York.
13. Lendren, D. Modlling in behavioral ecology. Chapman & Hal, London, UK.
14. Sokal, R.R. and F.J. Rohlf. Biometry. Freeman, San Francisco.
15. Snedecor, h.W. and W.G Cochran, Statistical methods. Affiliated East-West Press, New Delhi (Indian ed.).
16. Green, R.H. Sampling design and statistical methods for environmental biologists. John Wiley & Sons, New York.
17. Murray, J.D. Mathematical biology. Spinger-Verling, Berlin.
18. Pielou, E.C. The interpretation of ecological data : A primer on classification and ordination.

PRACTICAL WORK BASED ON PAPER I TO IV

Total No. of laboratory hrs. 480

I : Invertebrates :

1. Identification, classification & study of distinguishing features of important representatives from various groups (Protozoa to Hemichordata).
2. Study of permanent prepared slides (Protozoa to Hemichordata).
3. Anatomy :
 - (i) Nervous system and general anatomy: of commercially available mollusks such as *Sepia* and *Loligo*.
 - (ii) General Anatomy, Reproductive and Nervous System of Cockroach, Grasshopper.
 - (iii) Study of the arms of a starfish: water vascular system of starfish; general anatomy of a Holothurian : Aristotle's lantern of a sea-urchin with the help of charts/ models/ and digital techniques

Note: External features and anatomy should be studied preferably by digital techniques and the alternatives. Whenever live animal is studied it should be either pest or culturable species without painning them.

4. Permanent preparations and their study :
 - (i) Preparation of cultures of *Amoeba*, *Paramecium* and *Euglena*. Study of these protozoans using vital dyes.
 - (ii) Permanent preparations and study of *Amoeba*, *Paramecium* and *Euglena* from cultures, Vorticella from the pond water; flagellates from the gut of white ant and housefly; Trypanosomes in the blood of house rat; lifecycle stages of *Monocystis* from the seminal vesicle of Earthworm.
 - (iii) Study of live *Hydra* in nature or with digital alternatives.
 - (iv) Permanent preparations of trematodes, cestodes & nematodes found as parasites in sheep and pig.
 - (v) Permanent preparations and study of various parts of Cockroach / Grasshopper.
 - (vi) Permanent preparations of different materials to be provided for study.

II. Biological Chemistry :

1. Identification of Protein, Carbohydrates and Lipid.
2. Identification of different kinds of mono, di and poly saccharides.
3. Quantitative estimation of the following by spectrophotometric, semi-autoanalyser method.
 - (a) Carbohydrates : Glycogen and glucose.
 - (b) Proteins: Total proteins.
 - (c) Lipid: Phospholipids and cholesterol.
 - (d) Nucleic acids: DNA and RNA.
 - (e) Enzymes: Acid and alkaline phosphates.
2. Paper chromatography and Thin Layer Chromatography: Unidimensional chromatography using amino acids.
3. Paper electrophoresis and Gel (SDS PAGE) and Agarose electrophoresis; Determination of serum protein through paper and gel (SDS and Agarose electrophoresis)
4. Study of digestive enzymes in different parts of the alimentary canal (including salivary glands of the cockroach).

III. Physiology :

1. Simulations of operation of oscilloscope for recording neuro-electric activity & electro-cardiogram using digital techniques/ alternatives.
2. Simulations of Kymographic recording of muscle twitch, summation of twitches, colonic contractions, tetanus, fatigue & staircase phenomenon using digital techniques / alternatives.
3. Simulations of Kymographic recording of the heart beat & the study of the effect of electrical stimulation, various ligatures, drugs, etc using digital techniques / alternatives.
4. Study of spinal and convulsive reflexes using digital techniques/ alternatives.
5. Photometric determination of haemoglobin in blood sample.
6. Demonstration of the following in blood; clotting time, erythrocyte sedimentation rate, haemolysis & crenation.
7. Determination of blood urea value.

IV. Cell biology :

1. Observation of cellular organization of testis of cockroach and grasshopper; Acetocarmine & Fuelgen staining preparations/ slides/ digital techniques.
2. Study of mitosis in onion root tip and mammalian bone marrow cells.
3. Study of giant chromosomes in the salivary gland of *Chironomus* larva, *Drosophila*.
4. Vital and supra-vital staining (with Neutral red and Janus Green B) of cells of the testis of any insect pest/ rodent pest to study the mitochondria.

5. Chromosome counts in cells of the testis of an insect pest/ bone marrow cells of rodent pest.
6. Study of prepared microscopic slides, including those showing various cell types, mitosis, meiosis and giant Chromosomes.
7. Preparations and staining of Barr bodies.

V. Genetics :

1. Culture and identification of male and female *Drosophila*.
2. Identification of wild and mutant forms of *Drosophila*.
3. Monohybrid & Dihybrid inheritance in *Drosophila*.
4. Simple problems based on Mendelism to be done by the students.
5. Identification of blood groups in man.
6. Demonstration of sex chromatin.

VI. Statistical Methods in Biology :

1. Preparation of frequency tables and graphs.
2. Calculation of standard deviation, variance and standard error of the mean.
3. Calculation of probability & significance between mean using t-test.
4. Calculation of significance using Chi-square test.
5. Plotting the slope of a line on a graph; calculations of the slope of a line, coefficient and regression. Students shall have to maintain a complete record of the work done.
6. Preparation of histogram, bar diagram and line graph using computer.

VII. Molecular Biology and Microbiology :

1. SDS PAGE of soluble proteins and determination of molecular weight.
2. Molecular designing using computer.
3. Culture and staining of non-pathogenic bacteria.
4. Exercise based on DNA fingerprinting, DNA sequencing.

Live Zoology: Study of invertebrate fauna with particular emphasis on their taxonomy, relationships and habitat. Comparison of such faunal diversity of more than one study sites. Interaction between the different invertebrate groups if any. GIS (Geographical Information System) based documentation and presentation of invertebrate faunal diversity.

Note: (i) Use of animal for dissection and practical work is subject to the conditions that these are not banned under the wildlife protections act.

(ii) Those Institutions which are already having Zoology Museums should not procure Museum Specimens now onwards and should use charts / slides / models / photographs and digital alternatives in case of need. Those new institutions which are not having Zoology Museum in their Department should provide learning related to zoological specimens with the help of charts / slides / models / photographs and digital alternatives/ and visit of students to already established museums.

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M.SC. (FINAL) ZOOLOGY**PAPER V – BIOLOGY OF CHORDATES AND DEVELOPMENTAL BIOLOGY****Section – A****Biology of Chordates:**

1. Origin and outline classification of the chordates.
2. Interrelationships of Hemichordata, Urochordata and Cephalochordata and their relations with other Deuterostomes.
3. Life history of sessile and pelagic tunicates and ascidian, *Pyrosoma*, *Salpa*, *Doliolum* and *Oikopleura*.
4. Origin, evolution and adaptive radiation of vertebrates.
 - a) Geological time scale and fossils
 - b) Origin, evolution and general characters of Agnatha (Ostracoderms and Cyclostomes).
 - c) The early Gnathostome (Placoderms).
 - d) A general account of the Elasmobranchi, Holocephali, Dipnoi and Crossopterygi.
 - e) Adaptive radiation in bony fishes.
 - f) Origin and evolution and adaptive radiation of Amphibia.
 - g) Origin and evolution of reptiles; the conquest of land, Seymouria and related forms; Cotylosauria, basic skull types and outline classification of reptiles.
 - h) Dinosaurs types and evolutionary significance.
 - i) Living reptiles - a brief account of Rhynchocephalia, Chelonia, Crocodilia and Squamata.
 - j) Origin and evolution of birds.
 - k) Origin of flight; flight adaptations.
 - l) Origin of mammals
 - m) Primitive mammals (Prototheria & Metatheria)
 - n) A general survey of the main radiations in eutherian mammals, excluding detailed reference to individual orders.
 - o) Evolution of man; relationships of man with other Primates; fossil record of man's ancestry.

Section - B**Developmental Biology :**

5. Theories of Development : Preformation and Epigenesis.
6. Spermatogenesis
7. Oogenesis:
 - (a) Growth of oocyte and vitellogenesis.
 - (b) Organization of egg cytoplasm; role of the egg cortex.
 - (c) Morphogenetic determination in egg cytoplasm;
8. Fertilization ; significance of fertilization for development and the essence of activation of the egg.
9. Early embryonic development:

- (a) Patterns of cleavage, blastulation and gastrulation in chordates (tunicates to mammals).
- (b) Fate maps.
- (c) Morphogenetic movements.
- (d) Mechanics and significance of gastrulation.
- 10. Cytoplasmic determinants and autonomous cell specification
 - (a) Cell commitment and differentiation
 - (b) Germ cell determinants
 - (c) Germ cell migration.
 - (d) Progressive cell-cell interaction and cell specification fate
- 11. Body Axes
 - (a) Establishment of Body axes in mammals and birds
 - (b) Proximate tissue interactions
- 12. Causal basis of development : Primary embryonic induction:
 - (a) Concepts of potencies; prospective fates; progressive determination, totipotency and pluripotency, nuclear transfer experiment.
 - (b) Induction of the primitive nervous system (Spemann's primary organizer).
 - (c) Nature and regionally specific properties of inductor.
 - (d) Competence.
 - (e) Abnormal (heterogeneous) inducers.
 - (f) Chemistry and mechanism of action inducing substances.
 - (g) Cell differentiation and differential activity
- 13. Early vertebrate development
 - (a) Neurulation and ectoderm
 - (b) Mesoderm and endoderm
- 14. Cell diversification in early animal embryo
 - (a) *Xenopus* blastomeres
 - (b) Morphogen gradients
 - (c) Embryonic stem cells.
 - (d) Renewal by stem cells-epidermis
 - (e) Skeletal muscle regeneration
 - (f) Connective tissue cell family
- 15. Organogenesis :
 - (a) Morphogenetic processes in epithelia and mesenchyme in organ formation.
 - (b) Morphogenesis of the brain; neural crest cells and their derivatives.
 - (c) Development of the eye, heart and alimentary canal, accessory organs.
 - (d) Maternal contributions in early embryonic development.
 - (e) Genetic regulations of early embryo.

Section - C

Some Specific Aspects of Development:

- 16. Embryonic adaptations:
 - (a) Evolution of the cleidoic egg and its structural and physiological adaptations.

- (b) Development and physiology of the extra-embryonic membranes in amniotes.
- (c) Evolution of viviparity.
- (d) Development, types and physiology of the mammalian placenta.
- 17. Regeneration:
 - (a) Types of regeneration, physiological, reparative and compensatory hypertrophy, regenerative ability in chordates.
 - (b) Morphological and histological process in amphibian limb regeneration.
 - (c) Origin of cells of regenerations, re-differentiation, pattern formation during amphibian limb regeneration, reasons for the absence of limb regenerative ability in mammals. Methods for induction of regenerations
- 18. Tetrapod limb development.
- 19. Homeobox concept in different phylogenetic groups
- 20. Hemopoietic stem cells
 - (a) Stem cell disorders
 - (b) Blood cells formation
 - (c) Bone marrow transplants
 - (d) Gene therapy
- 21. Metamorphosis
 - (e) Amphibian metamorphosis
 - (f) Insect metamorphosis

Suggested Reading Material

- Alexander, R.M. The Chordata. Cambridge University Press, London.
- Barrington, E.J.W. The Biology of Hemichordata and Protochordata. Oliver and Boyd, Edinburgh.
- Bourne, G.H. The structure and functions of nervous tissue. Academic Press. New York.
- Carter, G.S. Structure and habit in vertebrate evolution - Sedgwick and Jackson, London.
- Eccles, J.C. The understanding of the brain. McGraw Hill Co., New York and London.
- Kingsley, J.S. Outlines of Comparative Autonomy of Vertebrates. Central Book Depot, Allahabad.
- Kent, C.G. Comparative anatomy of vertebrates.
- Malcom Jollie, Chordata morphology. East-West Press Pvt. Ltd., New Delhi.
- Milton Hilderbrand. Analysis of vertebrate structure. F.V. Ed, John Wiley and Sons Inc., New York ,
- Monielli, A.R. The chordates. Cambridge University Press, London.
- Smith, H.S. Evolution of chordata structure. Hold Rinehart and Winston Inc., New York.
- Sedgwick, A.A. Students Text Book of Zoology, Vol II
- Tansley, K. Vision invertebrates. Chapman and Hall Ltd., London.
- Torrey, T.W. Morphogenesis of vertebrates. John Wiley and Sons Inc.

New York and London.

Walters, H.E. and Sayles, L.D. Biology of vertebrates. MacMillan and Co., New York.

Wolstenholme, E.W. and Knight, J. (Ed.). Taste and Smell in vertebrates, J and A Churchill, London.

Romer, A.S. Vertebrate Body, 3rd Ed. W.B. Saunders Co., Philadelphia.

Young, J.Z. Life of vertebrates. The Oxford University Press, London.

Young, J.Z. Life of mammals, Oxford University Press, London.

Colbert, E.H. Evolution of the vertebrates, John Wiley and Sons Inc., New York.

Romer, A.S. Vertebrate Paleontology, 3rd Edn. University of Chicago Press, Chicago.

Clark, W.K. History of the Primates IV Edn. University of Chicago Press, Chicago.

Weichert, C.K. and Presch, W. Elements of chordate anatomy, 4th Edn. McGraw Hill Book Co., New York.

Messers, H.M. An introduction of vertebrate anatomy.

Montagna, W. Comparative anatomy. John Wiley and Sons Inc.

de Beer, S.G. Embryos and Ancestors. Clarendon Press, Oxford.

Andrews, S.M. Problems in vertebrate evolution. Academic Press, New York.

Waterman, A.J. Chordata structure and function. Macmillan Co., New York.

Joysey, K.A. and T.S. Kemp. Vertebrate evolution. Oliver and Boyd, Edinburgh.

Lovtrup, S. The phylogeny of vertebrate, John Wiley and Sons, London.

Barbour, T. Reptiles and Amphibians : Their habits and adaptations. Houghton Mifflin Co., New York.

Kingsley Noble, G. The Biology of the Amphibia. Dover Publications, New York.

Snyder, H. Amphibia and their ways. The McMillan Co., New York.

Andrews, S.M. Miles, R.S. and Walker, A.D. Problems in vertebrate evolution. Academic Press, New York.

S.F. Gilbert. Developmental Biology. Sinauer Associates Inc., Massachusetts.

Ethan Bier. The Cold Spring; Cold Spring Harbor Laboratory Press, New York.

PAPER VI : ECOLOGY AND ETHOLOGY

Section - A

1. Concepts of modern ecology.
2. Limiting factors :
Liebig's law of minimum, Shelford's law of tolerance: combined concept of limiting factors, conditions of existence as regulatory factors.

3. Analysis of Environment.
 - (a) The general environment.
 - (b) Role of physical factors; temperature, light water; atmospheric gases, the media, molar forces, the substratum, climatology.
 - (c) Brief review of important physical factors as limiting factor.
 - (d) Nutrients and environment.
4. Organization at the population level :
 - (a) General properties of population.
 - (b) Population growth : form and forces shaping the population growth.
 - (c) Measurement of Population. Simple numerical problems on measurement of population to be done.
 - (d) Animal aggregation and social life.
5. Organization at the community level :
 - (a) Biotic community concept.
 - (b) Community structure and concept of community dominance.
 - (c) Ecotone and concept of "edge effect".
 - (d) Pattern in communities : Stratification, zonation, activity, food web, reproductive and social.
 - (e) Community versus the continuum.
 - (f) Evolution of Communities; Palaeoecology; Community structures in past ages.
6. Ecological regulations :
 - (a) Succession in community : Basic types of succession convergence and divergence in succession; modifications in succession; concept of climax, monoclinal versus polyclinal theory; barriers & ecesis in succession; Biome.
 - (b) Fluctuations within community; eruptive cycle, fluctuation; causes of fluctuation, cycles.

Section-B

7. Environment and animals:
 - (a) Nature and constituents of ecosystem.
 - (b) Fundamental operation of ecosystem
 - (c) Flow of matter and energy in ecosystem
 - (d) Homeostasis in the ecosystem
 - (e) Cycling of chemical elements in ecosystem.
 - (f) Concept of productivity : Productivity of land and water.
8. Organization and dynamics of ecological communities :
The habitat approach: A detailed knowledge of extent, zonation, environment, biota, adaptations and communities of fresh water, marine, terrestrial & estuarine areas.
9. The ecological outlook :
Space ecology, nuclear radiation, population, resources & applied human ecology.
10. Ecosystem dynamics and management;
 - (a) Stability and complexity of ecosystems;
 - (b) Speciation and extinction;

- (c) Environmental impact assessment;
- (d) Principles of conservation; Conservation strategies;
- (e) Prospects and Strategies for Sustainable development.

Section-C

11. Introduction to Ethology.
Ethology as a branch of biology and its significance
12. Types of behaviour and their regulation :
 - (a) Feeding behaviour :
 - (i) Components of feeding behaviour; hunger and drive; directional movement, avoidance, eating, carrying and hoarding.
 - (ii) Factors influencing choice of food.
 - (iii) Nervous regulation of food and energy intake.
 - (b) Learning :
Habituation conditioned reflex; trial and error; latent learning; learning and discrimination imprinting; neural mechanism of learning.
 - (c) Instinctive behaviour; concept, phyletic descent and physiology.
 - (d) Motivated behaviour :
Drive, satiation & its neurophysiological control.
 - (e) Social behaviour in primates :
 - (i) Social signals, olfactory, tactile, visual, vocal.
 - (ii) Status : dominance & hierarchy territorial behaviour courtship & mating aggression.
 - (iii) Primate societies.
 - (f) Behaviour in birds : Behaviour of *Streptopelia* (ring dove) homing and migration.
 - (g) Reproductive behaviour in fish (Stickle back or any other fish).
 - (h) Social behaviour in insects :
- Communications; concealment behaviour.
 - (i) The role of pheromones (a general account).
13. Orientation :
 - (a) Classification of various types of taxes and kinesis.
 - (b) Flight orientation in locust.
14. Methods of studying behaviour: Brain lesions, electrical stimulation, drug administration.
15. Behavioural genetics: Single gene effect; multiple gene effect; behavioural variation in an individual; genetics and human behaviour.
16. Behaviour of domestic and Zoo animals.
17. Hormones and behaviour. Mammalian nervous system with special reference to the involvement of hypothalamus in the regulation of behavioural patterns.

Suggested Reading Material

Begon, M., J.L. Harper and C.R. Townsend. Ecology, individuals. Populations and communities. Blackwell Science, Oxford, U.K.
 Cherratt, J.M. Ecological concepts. Blackwell Sci. Publ. Oxford. UK.
 Elseth, B.D. and K.M. Baingartuer. Population biology. Van Nostrand Co.,

New York.

Jorgensen, S.E. Fundamentals of ecological modeling. Elsevier, New York.
 Krebs, C.J. Ecology. Harper & Row, New York.
 Krebs, C.J. Ecological methodology. Harper & Row, New York.
 Ludwig, J.A. and J.F. Reynolds, 1988. Statistical ecology. John Wiley & Sons, New York.
 Pianka, E.R. Evolutionary ecology. Harper & Row New York.
 Ricklefs, R.E. and G. Miller. Ecology, W.H. Freeman & Co., New York.
 Roughgarden, J., Ecological methods. Southwood, T.R.E.
 Swartzian, G.L. and S.P. Kaluzny. Ecological simulation primer. Macmillan, New York.
 Rof, D. The evolution of life histories. Theory and Analysis. Chapman & Hall, London, UK.
 Alcock, J. Animal behavior: An evolutionary approach. Sinauer Assoc., Sunderland, Mass. USA.
 Bradbury, J.W., and S.L. Vehrencamp. Principles of animal communication. Sinauer Assoc., Sunderland, Mass. USA.
 Clutton-Brock, T.R. The evolution of parental care. Princeton Univ. Press, Princeton, NJ, USA.
 Eibl-Eibesfeldt, I. Ethology. The biology of behavior. Holt, Rinehart and Winston, New York.
 Gould, J.L. The mechanisms and evolution of behaviour.
 Hauser, M. The evolution of communication. MIT Press, Cambridge, Mass. USA.
 Hinde, R.A. Animal behaviour: A synthesis of ethology and comparative psychology. McGraw-Hill, New York.
 Krebs, J.R. and N.B. Davies: Behavioural ecology. Blackwell, Oxford, U.K.
 Wilson, E.O. Sociobiology: The new synthesis. Harvard Univ. Press, Cambridge, Mass. USA.

PRACTICAL WORK BASED ON PAPER V & VI

1. Chordates

- (a) Taxonomy : Study of museum specimens or representative animals from all chordate groups (protochordates to Mammals).
- (b) Anatomy :
 - (i) General anatomy afferent and efferent arteries, cranial nerves, membranous labyrinth of any Major Carp (eg. *Labeo*) or demonstration of general anatomy afferent and efferent arteries, cranial nerves in *Scoliodon* using digital dissection
 - (ii) Demonstration of general anatomy, limb musculature, cranial nerves and eye muscles and their innervation in using frog digital dissection / computer software.
 - (v) General anatomy, major blood vessels and cranial nerves of any non-poisonous snake. Through charts / models/ computer software, study of differences between poisonous and non-poisonous snakes.

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- (vi) Flight muscles, perching mechanism, air sacs and anatomy of the neck region in the pigeon through charts / models/ computer software.
- (vii) Reproductive system and general anatomy of the house rat. Digital alternatives may be used.
- (c) Osteology : Comparative study of the axial and appendicular skeleton from fish to mammals, with particular reference to the important skull-types in reptiles, birds and mammals using charts / models / digital alternatives.
- (d) Permanent Preparations: Placoid, cycloid and ctenoid scales. Different types of muscle fibres of house rat.
- (e) Histology: A detailed study of the histology of tissues of house rat by microtomy techniques.

2. Developmental Biology :

- (a) Study of development of frog or toad:
 - (i) Observation in nature (egg, spawn, embryo, larvae and metamorphic stages),
 - (ii) Permanent microscopic slides of sections through successive embryonic and larval stages.
- (b) Study of development of Chick through :
 - (i) Permanent whole mounts of successive embryonic stages and.
 - (ii) Permanent microscopic slides of sections through representative regions of successive embryonic stages.

Note : Special emphasis should be laid on organogenesis and morphogenesis.

- (c) Removal of chick embryos 18, 21, 24, 33, 72 and 92 hours from the egg and their study and identification in the living state, permanent whole mounts of these embryo in a living state (9day old embryo may be used for the purpose.
- (d) Study of foetuses with placenta in the house rat. Digital alternatives may be used.

3. Ecology :

- (a) Measurement of climatic factors (atmospheric, water temperature and relative humidity.
- (b) Measurement of water and soil pH, edaphic factors of soil; Preparation of soil extract, determination of humidity in microhabitat. Alkalinity, water, pH, dissolved oxygen, free carbon dioxide, Alkalinity. Chloride, salinity, temporary and permanent hardness of water, velocity of current.
- (c) Measurement of Population density. Numerical problems of population determination to be done.
- (d) A file study of any one of the following habitats to be assigned to an individual or to a group of students.

4. Ethology :

- (a) Study of the process of learning in rat with the help of animal Maize analysis of the results of simple experiments.
- (b) Study of avoidance behaviour in rat, analysis of the result of these

experiments.

- (c) Imprinting in precocial birds.
 - (d) Chemical communication in the earthworm.
 - (e) Study of the food preferences and feeding behaviour of an insect pest.
 - (f) Study of the phototactic response in *Tribolium* / *Musca*/ *Drosophila*;
 - (g) Sound spectrum analysis of frogs, toads and bird's calls using computer software.
5. **Live Zoology:** Study of vertebrate fauna in Nature with particular reference to their identification up to species level. Study of different behavioural patterns of one representative of each vertebrate class in nature. Interaction of vertebrate with environment. GIS based documentation and presentation of faunal diversity of vertebrates. Reasons for the decline in population of vertebrates in the vicinity of the Institution concerned. A note on conservation plan of vertebrate fauna.
- (Note – (i) Use of animals for dissection/practical work is subject to the conditions that these are not banned under the wild life protection act.
(ii) Those Institutions which are already having Zoology Museums should not procure Museum Specimens now onwards and should use charts / slides / models / photographs and digital alternatives in case of need. Those new institutions which are not having Zoology Museum in their Department should provide learning related to zoological specimens with the help of charts / slides / models / photographs and digital alternatives/ and visit of students to already established museums.

SPECIAL PAPERS

3 hrs. duration

Max. Marks 100

PAPER VII (A) : CELL BIOLOGY**Section - A**

- 1. Concept of cell theory.
- 2. Cell types : Detailed structure of the different types of cells.
(i) Nerve cell (ii) Muscle cell (iii) Gland cell (iv) Blood cell.
- 3. Cell Membrane :
 - (a) Study of various models of the molecular structure of the cell membrane as suggested by Devson & Danielli, Robertson & Green : Other recent views on the subject.
 - (b) Molecular structure of the specialized modifications of the cell membrane (Cilia, flagella, myelin sheath etc.)
 - (c) Concept of cell surface: Electro kinetic properties of cell surface, their role in intercellular, interaction in cell fusion, Cell aggregation etc.
 - (d) Properties & functions of the cell membrane, with special reference to permeability.

Section - B

- 4. Cytoplasm :
 - (a) Generalized structure & composition of the cytoplasm.

- (b) Detailed discussion on the following cytoplasmic components with special reference to the biochemical and physiological aspects:
 (i) Endoplasmic reticulum (ii) Ribosomes (iii) Golgi body (iv) Mitochondria (v) Lysosomes, Peroxisomes & other related particles (vi) Centrioles.

5. Nucleus :

- (a) Structure & functions of the nuclear envelop.
 (b) Structure and Chemical organisation of the resting nucleus.
 (c) Nucleus & Nucleolar extrusions.
 (d) Chemistry and biosynthesis of nucleic acids.

Section - C

6. Chromosomes :

- (a) Structural, chemical and functional organization of the different types of chromosomes (autosomes, giant chromosomes, sex chromosomes supernumerary chromosomes etc.).
 (b) Chromosomal aberration.
 (c) Variation & evolution of chromosome numbers.

7. Cell Division :

- (a) Detailed Structural, chemical & physiological study of mitotic & meiotic divisions, with special reference to the mechanism of chromosome movement & organization of the spindle apparatus.
 (b) Mitotic poisons & their action.
 (c) Polyploidy.
 (d) Polysomy.

8. Gametogenesis :

- (a) Cytological cytochemical and endocrinological study on the developing male & female germ cells.
 (b) Physiology of ovum & spermatozoan.
 (c) Physiology of the union of gametes and the acrosome reaction.

PAPER VIII (A) : CELL BIOLOGY

Section - A

1. Specialized function of cytoplasmic components in a cell with special references to the molecular mechanism (Contractility, secretion, phagocytosis and pinocytosis).
 2. Cell and tissue culture :
 (a) Behaviour of cells in culture.
 (b) Primary and established cell lines; kinetics of cell growth.
 (c) Natural and defined media for culture,
 (d) Importance of cell and tissue culture.
 3. Generalized account of the mechanism of cell aggregation during development; *in vitro* studies.

Section - B

4. Chemical basis of "fixation" and "staining" and a discussion on the following techniques.
 (a) Freeze substitution.

- (b) Freeze drying.
 (c) Fresh and fixed frozen sections.
 (d) PAS. Metachromasia, Feulgen, lipid and protein staining techniques
 (e) Centrifugation and ultra-centrifugation.
 (f) Single two-dimensional & column chromatography.
 (g) Intra-vital and supra-vital staining.
 (h) Paper, gel and disc electrophoresis.
 5. Elementary concept of the principle & theory of microscopy as exemplified by the following:
 (a) Phase contrast microscopy.
 (b) Interference microscopy.
 (c) Polarizing microscopy.
 (d) Fluorescence microscopy.
 (e) Electron microscopy.
 (f) Ultra violet microscopy.

Section - C

6. A general account of the effect of ionizing radiation at the cellular level.
 7. Role and mechanism of action of the following enzymes at the cellular level :
 (a) ATPase
 (b) Succinic dehydrogenase
 (c) Acid and alkaline phosphatases
 (d) Hyaluronidase.
 8. Elementary ideas of the origin of following diseases :
 (a) Cancer
 (b) Glycogen storage disease.
 (c) AIDS.
 9. Cellular aspects of the process of aging.
 10. Cellular aspects of immunity and virus-cell interaction.

PRACTICAL WORK BASED ON PAPER VII (A) & VIII (A) CELL BIOLOGY

1. Handling & operation of following apparatus & equipments;
 (a) Phase Contrast Microscope.
 (b) Electrophoretic, Chromatographic & electrophysiological equipments.
 2. Microtomy - Wax, fresh, frozen and fixed frozen sections, sectioning of gelatin embedded material.
 3. Study of stained preparations of mitochondria and golgi bodies under the light microscope.
 4. Study of germ cells: smear preparation of spermatozoa from vas-deferens (vital staining) and permanent preparation of a single ovum.
 5. Biochemical estimations of the following in various tissues :
 (a) Lipids: lecithin, cephalin & cholesterol.
 (b) Carbohydrates : Glycogen.
 (c) Proteins :

- (d) Amino acids : chromatographic & electrophoretic separation.
- (e) Ascorbic acid.
- 6. Study of unfixed materials:
Unstained & live animal tissue : by phase contrast microscopy.
- 7. Histo-chemical demonstration :
(a) Acid haemalin of Baker & its modifications.
(b) Grkamoto's method.
- 8. Cytochemical Demonstration
(a) Millon's reaction.
(b) Ninhydrin Schiff method.
- 9. Histo-cytochemistry.
(a) Methyl green-pyronin -method
(b) Feulgen staining
(c) Periodic acid schiff method
(d) Alcian blue method.
- 10. Histo-cytochemical staining of Enzymes:
Staining of alkaline & acid phosphates in kidney, liver & nervous tissue by Gomori's method and azo dye technique.
- 11. Freeze-substitution and processing of the treated material.
- 12. Demonstration of bioelectric potentials, Oscillographic demonstration of nerve action potential.

Note : (i) Use of animal for dissection and practical work is subject to the conditions that these are not banned under the wildlife protection act.
(ii) External features and anatomy should be studied preferably by digital techniques and the alternatives. Whenever live animal is studied it should be either pest or culturable species without painning them.
(iii) Those Institutions which are already having Zoology Museums should not procure Museum Specimens now onwards and should use charts / slides / models / photographs and digital alternatives in case of need. Those new institutions which are not having Zoology Museum in their Department should provide learning related to zoological specimens with the help of charts / slides / models / photographs and digital alternatives/ and visit of students to already established museums.

PAPER VII (B) : ENVIRONMENTAL BIOLOGY

Section - A

- 1. Systems analysis including models in environmental biology.
- 2. Impact of environment at cellular level : Cellular interaction with environment.
- 3. Environment Physiology :
Basic Metabolic rate and body size
Metabolism and climatic adaptations :
Hibernation and aestivation. Poikilotherms and Homeotherms. Asphyxic responses.
Response to temperature and pressure. Haematological changes. Ther-

mal properties of water and survival limits. Acclimatization.

Section - B

A detailed study of different ecosystems :

Study will include biotic & a biotic components and their interrelationships, productivity & adaptations of animals.

4. Terrestrial ecosystems :

- (i) Grasslands. including grazing lands
- (ii) Forests : Characteristic of alpine, temperate & tropical forests. Stratification. High altitude with special reference to Himalayan Ecology.
- (iii) Deserts: Types and ecological attributes of desert biota.
- (iv) Taiga : Extent and ecological peculiarities.
- (v) Tundra : Extent and ecological peculiarities.

5. Aquatic Ecosystems :

- (i) Fresh water : Lakes including salt lakes, ponds streams, springs, rivers and marshes.
- (ii) Marine ecosystem : Zonation, fauna.
- (iii) Estuarine : Ecological peculiarities, adaptation including impact on fauna.
- 6. A general knowledge of Biogeography.

Section - C

- 7. Development & evolution of ecosystems, causes & kinds of succession. Diversity and productivity in relation to stages of succession and development.
- 8. Urban, rural and other man made ecosystems, their impact on animal life. Urbanization and industrialization. Socio-ecological impacts.

PAPER VIII (B) : ENVIRONMENTAL BIOLOGY

Section - A

- 1. History of man and his cultural evolution in relation to impact on environment.
- 2. **Management of Environment : Natural resources, their conservation and development.**
(i) Agriculture and forestry including pest management.
(ii) Wild life resources.
(iii) Mineral resources.
(iv) Aquaculture (Fresh and Marine)
(v) Energy resources
(vi) River basin.

Section B

- 3. Pollution (Monitoring, sources, effect and control)
(a) Water (b) Air (c) Land (d) Thermal (e) Noise (f) Radiation
- 4. Environment and Health.
(a) Urban health problem. Impact of urbanization stress, Health status and Health problem.
(b) Rural health problem.
(c) Impact of weather, natural disaster, pollution, water availability, food resources in relation to human health.

Section - C

5. Environmental toxicology :
Natural and man made toxicants occurring in the environment and their impact on animal life in different ecosystems. Safety measures.
6. Methodology for environmental analysis :
 - (a) Monitoring
 - (b) Analysis of physical and chemical factors.
 - (c) Statistical analysis.
 - (d) Bioassay techniques.

Practicals for Environmental Biology Based on VII & VIII B

1. Water quality analysis (Physico- chemical parameters).
 - (a) Temperature
 - (b) pH
 - (c) Dissolved oxygen
 - (d) Acidity
 - (e) Hardness
 - (f) Alkalinity
 - (g) Chloride
 - (h) Sulphates
 - (i) Total and dissolved solids.
 - (j) BOD
 - (k) COD
2. Air quality monitoring for :
 - (a) Settable matter
 - (b) Suspended particulate matter.
3. Microscopic examination of water :
Indicators of pollution, planktons, benthic and littoral fauna and flora.
4. Bioassays of polluted waters using Fish or other aquatic organisms, statistical analysis of ecological data.
5. Soil/ sediment analysis
 - (a) EC
 - (b) pH
 - (c) Alkalinity
 - (d) Organic matter
 - (e) Texture
 - (f) Salinity
6. Sampling procedures and report on a case study.
7. Field trip to any of the following habitats :
 - (a) Forest; Wild life sanctuary.
 - (b) Fresh water habitat
 - (c) Marine habitat
 - (d) Semiarid habitat
 - (e) Desert

(Students are expected to give complete Ecological Report of the trip including ecosystem structures, indicators and estimation of environmental degradation, if any)

PAPER VII (C): ENTOMOLOGY**Section - A**

1. Insect head, thorax, abdomen and their appendages.
2. Integument.
3. Muscular, digestive, circulatory, respiratory, excretory, reproductive, nervous and endocrine systems; sense organs, sound and light producing organs.

Section - B

4. Classification of insects upto orders and sub-orders.
5. Detailed Classification of important and selected super families and families of the following orders of economic importance : Orthoptera, Isoptera, Homoptera, Lepidoptera, Diptera and Hymenoptera.

Section - C

6. Social life in Isoptera and Hymenoptera, caste determination in social insects, life cycle of aphids.
7. A general idea of fossil insects, evolution of insects.

PAPER VIII (C) : ENTOMOLOGY**Section - A**

1. General idea of damage caused by pests.
2. Principal methods of pest control including IPM.
3. Insecticide; their chief types, modes of action and methods of application; a general idea of appliances used in the application of insecticide and their safe handling.
4. A general knowledge of chemosterilants, attractants, repellants pheromones, growth regulators and other compounds.

Section - B

5. Development of resistance to chemicals.
6. Life history, damage caused and control of major pests of the main crops: wheat, paddy, maize, jowar, millet, sugar cane, cotton and oil seeds.
7. Stored grain pests (including general idea of storage)
8. A general idea of plant protection organization in India.

Section - C

9. Beneficial insects : silkworm, honey bee and lac insect and industries related to them.
10. Important insects used in biological control.
11. Ecology : Effects of physical factors, Intra-specific and inter-specific relations; dynamics of population.
12. Embryology : Embryonic and post- embryonic development; diapause.

ENTOMOLOGY PRACTICAL BASED ON PAPER VII(C) & VIII(C)

1. Knowledge and use of equipment for the collection and preservation of insects; insect net, lulling bottle, spreading board, insect box, device for inflating larva, light trap, etc.

2. Collection and preservation of insects and their different stages.
3. Collection of seasonal insects, nocturnal insects, aquatic insects, crop pests, stored grain pests and insects of medical and veterinary importance.
4. Identification of insects from various orders prescribed for study in the syllabus.
5. Permanent-preparations : wings, mouth parts, antennae, legs, spiracles etc. of insects, sting of the honey bee.
6. Collection and preservation of insects and their different stages.
7. Dissections of grasshopper, house cricket, bug, butterfly, housefly, honey bee, wasp, beetle to study important features of the digestive, circulatory, respiratory, excretory, nervous, reproductive and neuro-endocrine systems.
8. Familiarity, with techniques and appliances of applying insecticides, experiments for testing the insecticides.
9. Knowledge of rearing insects and of maintaining the insectary.
10. Micro-technical procedures.
11. A tour to visit important centres of entomological studies

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 (ii) External features and anatomy should be studied preferably by digital techniques and the alternatives. Whenever live animal is studied it should be either pest or culturable species without painning them.
 (iii) Those Institutions which are already having Zoology Museums should not procure Museum Specimens now onwards and should use charts / slides / models / photographs and digital alternatives in case of need. Those new institutions which are not having Zoology Museum in their Department should provide learning related to zoological specimens with the help of charts / slides / models / photographs and digital alternatives/ and visit of students to already established museums.

PAPER VII (D) FISH BIOLOGY

Section – A

1. General account and phylogenetic significance of ostracoderms and placoderms.
2. Classification of Fishes, with distinguishing characters of the principal subdivisions.
3. Origin and adaptive radiation of various groups
4. Geographical distribution
5. Body form and locomotion.

Section – B

6. Integument and exoskeleton.
7. Structure, modification and functions of fins.
8. Theories of origin of median and paired fins.
9. Endoskeleton.

10. Musculature
11. Food & alimentary canal, physiology of digestion.
12. Blood vascular system, and circulation of blood.
13. Respiratory organs, physiology of respiration and regulation of breathing, air-breathing organs.

Section – C

14. Structure, function and physiology of the swim-bladder.
15. Weberian apparatus.
16. Excretory organs and the Physiology of excretion, osmo-regulation.
17. Nervous system and sense organs.
18. Endocrine glands, hormones & reproductive behaviour, gonads, reproduction development and hatching, viviparity.

PAPER VIII (D) FISH BIOLOGY

Section – A

1. A general survey of world fisheries, survey of principal fisheries of India (Fresh water, estuarine and marine).
2. Plankton in relation to fisheries.
3. The biology of Indian major carps, catfishes, Hilsa, sardine mackerel, sharks, prawns and oysters.
4. Pisci-culture and its importance, with special reference to India.
5. A brief outline on the methods of fishing in fresh waters of India.

Section – B

6. Bio- chemical composition of fish; fish as food.
7. Bi-products of fishing industry, with special reference to India.
8. Ecological factors affecting the life of fishes; marine, ecosystems.
9. Fish and mankind.
10. Age and growth studies.
11. Estimation of population number and mortality rates in fresh waters.
12. Fecundity; eggs and life history including a generalized classification of maturity stages; estimation of fish production with special reference to fresh water.
13. Aquaria and their uses, setting up and maintenance of aquaria.
14. Exotic fishes and their role in Indian fresh waters.

Section – C

15. Diseases of fishes (symptoms, etiology and treatment).
16. Problems of fresh water pollution in relation to fisheries with special reference to India
17. Coloration .
18. Bioluminescence
19. Electric organs
20. Poisons and venoms
21. Sound producing organs
22. Courtship and parental care, a general study of fish behaviour.
23. Migration and its causes.

24. Conditions of life in hill streams and deep sea, adaptations of fish living in these habitats.

FISH BIOLOGY PRACTICAL BASED ON PAPER VII (D) AND VIII (D)

- Complete anatomy of a teleost, represented by *Wallago*: external features, general viscera; including the urinogenital organs, jaw and lateral musculature, including the nerve supply, afferent and efferent branchial blood vessels, brain and cranial nerves; eye muscles and their innervation; membranous labyrinth, Weberian ossicles- swim-bladder connection, dry and alizarin preparations of the skeleton and its study.
- Dissection of the head of any flat fish (pleuronecti forms) with reference to its asymmetry.
- Dissection of their breathing organs in *Anabas*, *Clarias*, *Channa* and *Heteropenustes*, showing the blood supply wherever possible.
- External features afferent and efferent branchial blood vessels, cranial nerves and membranous labyrinth of *Dasyatis* or any other skate or ray.
- Permanent preparations and study of ampulla of Lorenzini; dermal and pharyngeal denticles, cycloid and ctenoid scales.
- Micro-technical procedures: Preparation and study of serial sections, of a larval fish and representative tissues and organs of fish.
- Collection of local fishes and their identification upto the species level; study of the available museum specimens.
- Hydro-biological studies:
 - Analysis of water to determine the pH, free carbon dioxide; dissolved oxygen, chlorides, calcium, total alkalinity and total salinity.
 - Collection, estimation and analysis of plankton.
 - Permanent preparation and identification of planktons.
- Biochemical and physiological:
 - Estimation of glycogen in liver.
 - Determination of pool size or free amino acids of muscle or blood plasma through chromatography.
 - Effect of epinephrine on the chromatophores.
 - Induced spawning.
 - Active transport in tubule.
- Field studies:
 - Periodical visits to a local fishing farm of fish centre to gain a first hand knowledge of its piscicultural practices and fisheries activities.
 - A week's tour of an inland fisheries research station of pisciculture centre. The suggested places for the tour are Udaipur, Rana Pratap Sagar Dam at Kota, Alwar, Bhartapur, Allahabad, Cuttack and Barrackpore.
 - A week's stay and work at an important marine Biological or fisheries centre in the country. The suggested places for this work are other several Central Institute of Fisheries Education at Bombay and National Institute of Oceanographic Research at Goa.

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- (ii) External features and anatomy should be studied preferably by digital techniques and the alternatives. Whenever live animal is studied it should be either pest or culturable species without painning them.
- (iii) Those Institutions which are already having Zoology Museums should not procure Museum Specimens now onwards and should use charts / slides / models / photographs and digital alternatives in case of need. Those new institutions which are not having Zoology Museum in their Department should provide learning related to zoological specimens with the help of charts / slides / models / photographs and digital alternatives/ and visit of students to already established museums.

PAPER VII (E) : ENDOCRINOLOGY

Section - A

- Historical background, "Scope and status" of endocrinology.
- Study of the following major endocrine glands of vertebrates.
 - Pituitary: General, developmental and comparative anatomy, functional cytology of the pituitary gland and mammalian, and sub-mammalian vertebrates, adenohypophyseal hormones their chemistry and physiology; chromatophore regulation among vertebrates; neurohormonal peptides; their chemistry and phylogenetic distribution; formation, storage, release and transport of neurohypophyseal principles; effects of hypophysectomy pituitary stalk secretion and transplantation.
 - Thyroid: General developmental and comparative anatomy, evolution of thyroidal function; biochemistry of thyroid hormones; biological actions of thyroid hormones and their interrelationship with other endocrine secretion, effects of thyroidectomy; calcitonin, its chemistry and physiology.

Section - B

- Parathyroid: General, developmental and comparative anatomy; biochemistry and physiology of the parathyroid hormone; effects of parathyroidectomy.
 - Pancreatic islets: General developmental and comparative anatomy; biochemistry and physiology of insulin and glucagon; effects of pancreatotomy.
 - Adrenal: General development and comparative anatomy, chromaffin tissue; biochemistry and physiology of catecholamines; the sympathetico-chromaffin complex steroideogenic tissue; structure and nomenclature of steroid hormones, effects of adrenalectomy.
 - Pineal: General development and comparative anatomy; biochemistry and physiology, the pineal principles.
- Chemical messenger : Mechanism of hormone action.

Section - C

- Endocrine integration : Diffuse effects of hormones; neoplastic growth.

migration in birds and fishes; bird plumage, hibernation: osmoregulation; blood pressure regulation.

5. Vertebrate neuroendocrinology : Ultrastructure and function of the neuro secretory cell, hypothalamo-hypophyseal relationship, hypothalamus in relation to higher nervous centres, other neuro-secretory systems in vertebrates; the urophysis, the subcommisural organ and the pineal complex.
6. Invertebrate neuroendocrinology : Anatomy and physiology of the endocrine and neuro endocrine systems of Annelida, Arthropoda and Mollusca.

PAPER VIII (E) : ENDOCRINOLOGY

Section – A

1. Hormonal control or sex differentiation nuclear sex.
2. The female reproductive system: Comparative anatomy and physiology of the mammalian and sub-mammalian ovary and sex accessory structures, ovarian hormones and their functions.
3. The male reproductive system: Comparative anatomy and physiology of the mammalian and sub-mammalian testis and sex accessory structures, semen and its biochemistry, testicular hormones and their functions.

Section – B

4. The gonadal hypophyseal-hypothalamus relationship.
5. Breeding seasons in vertebrates, evolution of viviparity, induced spawning in fish and frog.
6. Endocrinology of fertilization, implantation, delayed implantation, parturition and lactation.
7. Placenta as an endocrine tissue foeto-placental unit.
8. Functional aspects of chemical, mechanical and surgical control of male fertility in laboratory mammals and the human.
9. Functional aspects of chemical, mechanical and surgical, control of female fertility in laboratory mammals and the human.
10. Pheromones: Control of fertility in insects.

Section – C

11. Prostaglandins: Types, chemistry, mechanism of action and their effects on mammalian reproduction.
12. Hormonal imbalance and major endocrine disease:
 - Gigantism.
 - Acromegaly.
 - Dwarfism.
 - Addison's disease.
 - Cushing's syndrome.
 - Goitre.
 - Cryptorchidism.
 - Hypogonadism

Amenorrhoea.
Diabetes mellitus.
Tetany.

ENDOCRINOLOGY PRACTICAL BASED ON PAPER VII(E) & VIII(E)

1. Dissection and gross examination of various endocrine glands of representatives vertebrates.
2. Microscopical study of various endocrine glands of representative vertebrates through micro-technical procedure.
3. Study of the estrous cycle in mouse or rat by the vaginal smear technique.
4. Surgical procedures: castration, ovariectomy, adrenalectomy, thyroidec-tomy and hypophysectomy.
5. Bioassays for estimations, androgens and anti-estrogens, the Aschiem-Zondek pregnancy test.
6. Biochemical estimations of cholesterol content in adrenal tissue glyco-gen in uterine tissue.
7. Sperm count.
8. Study of the sex chromatin.
9. Effect of epinephrine on chromatophores in fish.
10. Study of microscopic slides of endocrine and related structures.

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PAPER VII (F) MOLECULAR DEVELOPMENTAL BIOLOGY

Section-A

Historical review of main trends and thoughts in embryology :
Concept of embryology and Developmental Biology. Theoretical and experimental embryology. Ontogenetic development and embryology. Importance of Developmental Biology in modern biomedical sciences.
Meiosis and significance of sexual reproduction :
Reproductive cycles and their hormonal control. Control of ovulation and induced breeding.

Gametogenesis :

Molecular aspects of spermatogenesis and oogenesis. Regulation of multiplication and maturation. Active transportation during oocyte development. molecular aspects of vitellogenesis, maturation of oocyte. Structure and biochemistry of egg and molecular changes during maturation. Nuclear activity during the growth of oocyte and organization of egg cytoplasm.

Section -B**Fertilization :**

Recognition of egg and sperm, gamete binding and recognition in mammals, Reaction of spermatozoa, sperm motility, capacitation, acrosome reaction gamete fusion and prevention of polyspermy, Reaction of egg, activation of egg metabolism, molecular regulation of development, rearrangement of egg cytoplasm, cortical reaction, preparation for cleavage. Elementary knowledge about artificial fertilization and IVF techniques. Sperm banks, artificial insemination, preservation techniques

Comparative account of cleavage in insects, frogs, chick and mammals : Cleavage patterns and their control. Chemical changes during cleavage. Role of egg cortex, morphogenetic gradients in egg cytoplasm, manifestation of maternal genes during cleavage. Mechanism of cleavage- cleavage cycle, maturation promoting factors. Role of cytoplasm and nucleus during early development.

Gastrulation :

Mechanism of gastrulation, morphogenetic movements, selective affinities of cells as a determining factor in cellular rearrangements, morphogenetic movements in epithelia, morphogenetic movements in mesenchyme. mechanism of changes in shape of cells during morphogenesis, general metabolism during gastrulation. Gene activity during gastrulation, involvement of parental genes in development. Comparative account of gastrulation in sea urchin, amphioxus, fish, amphibian, bird and mammal. Fate map, methods of their construction and their utility. Comparative topographical relationship of the presumptive areas in early embryos of amphioxus fishes, amphibians and birds.

Section- C**Genes, Development and related techniques :**

The embryological origin of gene theory, incidences of genomic equivalence., amphibian cloning, restriction of nuclear potency and concept of pluripotency of somatic cells, concept of totipotency – Steward's experiment.

Differential gene regulation :

Differential gene regulation in *E. coli*, the concept of differential gene expression in insect model, nucleic acid hybridization technique, cloning from genomic DNA, DNA hybridization within and across the species. DNA sequencing techniques, sequence search, alignment and homologies. Analyzing mRNA through cDNA libraries, RNA localization tech-

niques, finding rare message by PCR, determining the functions of g. determining the functions of message

Cellular basis of morphogenesis :

Differential cell affinity, the molecular basis of cell cell adhesion, cell adhesion molecules, molecular regulators of development, molecular basis of migrational specificity, molecular basis of differential substrate specificity.

Suggested Readings

- de Beer, S.G. Embryos and Ancestors. Clarendon Press, Oxford.
 Barbiur, T. Reptiles and Amphibians : Their habits and adaptations. Hongton Miffm Co., New York.
 Kingsely Noble, G. The Biology of the Amphibia. Dover Publications, New York.
 Gilbert, S.F. Developmental Biology. Sinauer Associates Inc., Massachusetts. 4th Edition.
 Walbot V and Holder, N. Developmental Biology, Random House New York
 Saunders, J.W. Developmental Biology Patterns Problems and Principles. Macmillan Publishing Comp. Inc. New York.
 Balinsky, B.I. An Introduction to Embryology Holt- Saunders International Editions.
 Wolpert, L. Principles of Development Oxford Univ. Press
 Wallace, H. Vertebrate limb regeneration John Willey and Sons
 Malacinski, G.M. Developmental Genetics of higher organisms – a primer in Developmental Biology. Collier Macmillan Publishers London
 O'Rahilly, R. and Muller F., Human Embryology and Teratology. John Willey and Sons
 Goss, R. Principles of Regeneration. Academic Press New York
 Schmidt A.J. Cellular Biology of Vertebrate Regeneration and Repair. The University of Chicago Press.

PAPER VIII (F) MOLECULAR DEVELOPMENTAL BIOLOGY**Section - A**

1. Cell Differentiation :
 - (a) Definition. Biochemical basis of differentiation; structural and biochemical changes during differentiation of muscle, cartilage, vertebrate pigment cells, lens and lens fibers, and epidermis
 - (b) The reversibility and inheritance patterns of gene activity. Control of specific gene expression. Models of cell differentiation.
2. Developmental genetics:
 - (a) Role of nucleus and cytoplasm in development.
 - (b) Nuclear transplantation in Amphibia.
 - (c) Somatic cell hybridization.
 - (d) Differential gene function during development, chromosomal puffing; differential synthesis and utilization of various types of RNA during

embryogenesis

Section- B

3. Patterning the vertebrate body plan :
 - (i) Setting up the body axes. Origin and specification of the germ layers.
 - (ii) Somite formation and patterning
 - (iii) Role of organizer regions and neural induction
 4. Development of *Drosophila* body plan :
 - (i) Maternal genes in set up of body axis
 - (ii) Zygotic genes in patterning the early embryo
 - (iii) Segmentation-activation of the pair rule genes
 - (iv) Segment polarity genes and compartments
 - (v) Segmentation selector and homeotic genes
 5. Normal table of development of anuran. Metamorphosis in anurans. Hormonal control of metamorphosis
 6. Abnormal development:
 - (a) Abnormal Growth
 - (i) Teratomas
 - (ii) Malignancy, general characteristics and properties of cancer cell.
- Oncogenes and carcinogenic agents.
- (b) Teratology:

Types of anomalies; genetic effects (peilotropism; phenocopies; analization) environmental effects, teratogenic agents. General mechanism of action of teratogenic agents.

Section -C

7. Limb development and Regeneration in vertebrates :
 - (a) Pattern formation in the limb, concept of limb field, mesenchyme- AER interactions, determination of limb fields by homeotic genes
 - (b) Regeneration of vertebrate limb- Wound healing, source of cells for regeneration; dedifferentiation, redifferentiation, pattern organization- proximo distal, dorso-ventral and anteroposterior, positional informations, rule of distal transformation of blastema, retinoids in regeneration-enhancement of developmental potencies of cells by retinoids. Homeotic transformations, genes and regeneration
 - (c) Loss of ability of organ regeneration in vertebrates. Finger regeneration in mouse. Induction of regeneration in non- regenerative cases.
8. Cell tissue and organ culture :
 - (a) Basic requirements design of the laboratory.
 - (b) Balanced salt solutions; pH control; use of antibiotics.
 - (c) Culture media; natural and chemically defined
 - (d) Methods of preparing cells, tissues and organs for culture *in vitro*.
 - (e) Contribution of cell, tissue and organ culture studies in developmental biology, medicine etc.
 - (f) Embryo culture techniques (New's ring technique, Auerbach's embryo culture technique.

Suggested Readings

1. de Beer, S.G. Embryos and Ancestors. Clarendon Press, Oxford.

2. Barbiur, T. Reptiles and Amphibians : Their habits and adaptations. Hongton Miffm Co., New York
3. Kingsely Noble, G. The Biology of the Amphibia. Dover Publications, New York.
4. Gilbert, S.F. Developmental Biology. Sinauer Associates Inc., Massachusetts. 4th Edition.
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6. Saunders, J.W. Developmental Biology Patterns Problems and Principles. Macmillan Publishing Comp. Inc. New York.
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11. O'Rahilly, R. and Muller F., Human Embryology and Teratology. John Willey and Sons
12. Goss, R. Principles of Regeneration. Academic Press New York
13. Schmidt A.J. Cellular Biology of Vertebrate Regeneration and Repair. The University of Chicago Press.

PRACTICAL WORK BASED ON PAPER VII (F) & VIII (F) MOLECULAR DEVELOPMENTAL BIOLOGY

1. Study of gametes, and various types and patterns of cleavage.
2. Early development in frog / toad.
3. Study of living embryos of the chick after 3 to 12 days of incubation.
4. Demonstration of cell death by vital staining.
5. Study of blood circulation in tail tip of amphibian larvae.
6. Study of Fluorosis during the development of amphibians.
7. Study of metamorphic stages of anuran.
8. Regeneration studies on amphibian tadpole (tail or limb) using digital techniques. Studies on the effects of retinoids on pattern formation during limb and tail regeneration using digital techniques.
9. Development of organs as chorio-allantoic grafts on chick embryos.
10. Permanent mounting of chick embryos.
11. Preparation and study of serial sections of successive embryonic stages.
12. Staging of tetrapod embryos in one animal species.
13. Effect of hormones on metamorphosis in insects by ligature experiments.
14. Effect of hormones on metamorphosis in anurans.
15. Explant culture of chick embryos on agar.
16. Teratological experiments on one of the species on which normal development was studied. Teratological effects of retinoid during development of heart and skeleton in mammals.
17. Molecular control of Development of *Drosophila*- Expression of seg-

- mental genes during *Drosophila* development.
18. Demonstration of Imaginal discs of *Drosophila*
 19. Sound call, analysis and application in identification of amphibian species..
 20. SDS-PAGE electrophoresis-to study change in profiles of soluble proteins during development.
 21. To study effects of known cytological markers such as actinomycin-D, tunicamycin, cyclohexamide etc. on development.
 21. Aurbach's and New's ring culture techniques using chick embryos
 22. Embryo lifting technique and culture -early chick embryo.
 23. Biochemical changes during development - protein, nucleic acid-semi auto analyser study.
 24. T3, T4, TSH profiles during amphibian metamorphosis and comparison with mammalian development.
 25. Identification of antibodies development using ELISA.
 26. Demonstration of endonuclease activity on DNA fragment.
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M.SC. ZOOLOGY (PREVIOUS)

Scheme of Practical Examination & Distribution of Marks

First Day

(Duration 5 hrs)

(a) Exercise in Biological Chemistry.	24 Marks
(b) Exercise in Cell Biology	12 Marks
(c) Exercise in Invertebrate Taxonomy	08 Marks
(Using Taxonomic Key)	
(d) Exercise in Statistical methods	12 Marks
(e) Identification and comments on Spots (eight)	24 Marks
(f) Viva- voce	10 Marks
(g) Class Record	10Marks
G Total	100 Marks

Second Day

(a) Internal organization of invertebrate	08 Marks
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(b) Permanent preparation	10 Marks
(c) Exercise in Physiology	12 Marks
(d) Exercise in Genetics	10 Marks
(e) Exercise based Molecular Biology	10 Marks
(f) Exercise based on Microbiology	10 Marks
(f) Live Zoology: Study report of animals in Nature	20 Marks
(g) Viva- voce	10 Marks
(h) Class Record	10 Marks
G Total	100 Marks

M.SC. ZOOLOGY (FINAL)

(Duration 5 hrs.)

Scheme of Practical Examination & Distribution of Marks

First Day

(a) Internal organization of vertebrate	10 Marks
(b) Permanent Preparation	05 Marks
(c) Exercise in Developmental biology	08 Marks
(d) Exercise in Ecology	08 Marks
(e) Exercise in Ethology	05 Marks
(f) Identification and comments of spots (eight)	24 Marks
(g) Live Zoology: Study report of animals in Nature	20 Marks
(h) Viva-voce	10 Marks
(i) Class Record	10 Marks
G Total	100 Marks

Second Day

(A) Cell Biology

(a) Biochemical estimation	20 Marks
(b) Exercise on histo-chemical or cyto-chemical techniques	16 Marks
(c) Light Microscopic Preparation of Mitochondria / Golgi bodies / spermatozoa/ single ovum	08 Marks
(d) Microtomy	12 Marks
(e) Identification and comments on Spots (eight)	24 Marks
(f) Viva-voce	10 Marks
(g) Class Record	10 Marks
G Total	100 Marks

(B) Entomology

(a) Dissection	16 Marks
(b) Permanent preparation	08 Marks
(c) Identification of 5 insects using taxonomic key	20 Marks
(d) Microtomy	12 Marks
(e) Identification and comments on Spots (eight)	24 Marks
(f) Viva-voce	10 Marks
(g) Class Record	10 Marks
G Total	100 Marks

(C) Fish Biology

(a) Major Dissection	20 Marks
(b) Minor dissection/ permanent preparation/ species identification using taxonomic key	08 Marks
(c) Hydro-biological/biochemical/physiological exercise.	08 Marks
(d) Microtomy	12 Marks
(e) Identification and comments on Spots (eight)	24 Marks
(f) Viva-voce	10 Marks
(g) Class Record	10 Marks
(h) Field study- project report (Survey to a Pisciculture unit)	08 Marks
G. Total	100 Marks

(D) Environmental Biology

(a) Water quality analysis/ quality Monitoring	15 Marks
(b) Microscopic Examination of water/ sampling method	15 Marks
(c) Bioassay method/ Statistical method	15 Marks
(d) Soil analysis	15 Marks
(e) Field trip/ project report	20 Marks
(f) Viva- voce	10 Marks
(g) Class Record	10 Marks
G. Total	100 Marks

(E) Endocrinology

(a) Dissection or surgical procedure	12 Marks
(b) Exercise on bioassay of hormone administration effects	10 Marks
(c) Quantitative estimation of glycogen/cholesterol/ ascorbic and/fructose in given endocrine tissue	12 Marks
(d) Exercise on sperm count/vaginal cycle/effect of Epinephrine on fish chromatophores	08 Marks
(e) Microtomy	14 Marks
(f) Identification and comments on Spots (eight)	24 Marks
(g) Viva- voce	10 Marks
(h) Class Record	10 Marks
G. Total	100 Marks

(F) Molecular Developmental Biology

1. Exercise on living embryos/ Teratological experiments	10
2. Exercise on metamorphosis/ Regeneration	05
3. Exercise on cell death / chromosomes	08
4. Exercise on molecular regulation of development	05
5. Microtomy	08
6. Identification and comments on spots (eight)	24
7. Viva- voce	10
8. Report on experimental observations/ project report	20
9. Class Record	10
G. Total	100 Marks