



UNIVERSITY OF RAJASTHAN
JAIPUR

SYLLABUS

M.Sc. ZOOLOGY

(ANNUAL SCHEME)

M.Sc. (Previous) Examination 2017-2018

M.Sc. (Final) Examination 2018-2019

Dy. Registrar
(Acad. Aff.)
University of Rajasthan
JAIPUR



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	Quantitative Biology and Population Genetics

LABORATORY EXERCISES, SEMINAR

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

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

- (i) Question number 1 will be compulsory and will have 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.

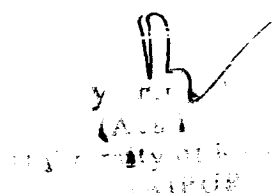
PAPER I: BIOSYSTEMATICS AND TAXONOMY

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
 - 4.1 Dimensions of speciation – Types of lineage changes; production of additional lineage.


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- 4.2 Mechanisms of 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.

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

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- 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. Barington, F.J.W., Invertebrate Structure and Function. Thomas Nelson and Sons Ltd., London.
2. Barnes, R.D., Invertebrate Zoology, W.B., Saunders Co., Philadelphia.
3. Cad, G.P., Animal Parasitism, Prentice Hall Inc., New Jersey.
4. Hyman, L.H., The Invertebrates, Smaller Coelomate Groups, Vol. 5, Mc.Graw Hill Company, New York.
5. Hyman, L.H., The Invertebrates, Vol. 1, Protozoa through Ctenophora, Mc.Graw Hill Company, New York.
6. Hyman, L.H., The Invertebrates, Vol. 2, Mc.Graw Hill Company, New York.
7. Hyman, L.H., The Invertebrates, Vol. 8, Mc.Graw Hill Company, New York.
8. Parker, T.J., Haswell, W.A., Text Book of Zoology, MacMillan Co., London.
9. Russel-Hunter, W.D., A Biology of Higher Invertebrates. Mc Millan Company Ltd, London.
10. Sedwick, A., Student Text Book of Zoology, Vol I, II, and III, Central Book Depot, Allahabad.

PAPER III: MOLECULAR BIOLOGY & BIOTECHNOLOGY

Duration: 3 Hours

Max. Marks: 100

Periods : 80

1. DNA: 5
 - 1.1 Equivalence rule
 - 1.2 DNA structure : Primary & Secondary
 - 1.3 Packaging of DNA: Nucleosome, Solenoid & Scaffold
2. DNA replication 5
 - 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
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 10
 - 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 10
 - 6.1 Holliday junction, gene targeting, gene disruption
 - 6.2 FLP/FRT and Cre/lox recombination
 - 6.3 RecA and other recombinases

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- 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 map based cloning
- 7.3 Southern and fluorescence, *in-situ* 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 *In Vitro* fertilization and embryo transfer.
- 9.3 Embryo sexing and cloning
- 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., Rafif M., 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 Harbor Laboratory 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 Adaptations to very cold environments
2. Ionic and Osmotic Balance 8
 - 2.1 Osmoregulation vs. Osmoconforming
 - 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


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5.2	Neurons and membrane excitation	
5.3	Electrochemical potentials	
5.4	Action potentials	
5.5	Transmission between neurons	
5.6	Synapses and neurotransmitters	
5.7	Memory and learning	
6.	Sensory Transduction	10
6.1	Sensing the environment	
6.2	Auditory receptors	
6.3	Chemoreceptors, Taste and smell, homing in Salmon	
6.4	Mechanoreceptors: Tactile systems and escape responses	
6.5	Vision and photoreception	
6.6	Thermoreception and infrared detection: Prey detection in snakes.	
6.7	Echolocation and bats	
7.	Digestion and Metabolism	5
7.1	Nutritional uptake and distribution	
7.2	Effects of starvation	
8.	Stress Biology	10
8.1	Basic concept of environmental stress and strain: concept of elastic and plastic strain; stress resistance, stress avoidance and stress tolerance.	
8.2	Adaptation, acclimation and acclimatization	
8.3	Concept of homeostasis	
8.4	Physiological response to oxygen deficient stress	
8.5	Physiological response to body exercise	
8.6	Meditation, yoga and their effects	
9.	Endocrinology	15
9.1	Aims and scope of endocrinology	
9.1.1	Discovery of hormones.	
9.1.2	Hormones as messengers.	
9.1.3	Classification of hormones	
9.2	Phylogeny of endocrine glands (Pituitary, pancreas, adrenal, thyroid, 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, Padova, 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., Ralphs, 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.
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 5
 - 4.1 Protein folding and dynamics.
 - 4.2 Folding overview: The Levinthal paradox.
 - 4.3 Condensation and molten globules.
 - 4.4 Ramchandaran plots and amino acid propensities.
 - 4.5 Catalysis and assistance.
 - 4.6 Amino acid sequence variation and membrane protein folding.
 - 4.7 Chaperonin-assisted protein folding.
5. Allostery (Hemoglobin), Myoglobin structure and oxygen binding 3
 - 5.1 Hemoglobin subunits cooperativity, the Hill coefficient.
 - 5.2 Quaternary 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 steroids. 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 B ₁₂ .	
7.3	Phenolics and alkaloids: Structure, biological properties and functions.	
8.	Covalent properties of nucleic acids	5
8.1	Modified nucleosides.	
8.2	Properties of polynucleotides.	
8.3	Secondary and tertiary structure.	
9.	Nucleic acid structure	5
9.1	Duplex stability.	
9.2	Hybridization.	
9.3	RNA structure.	
9.4	Hairpin and pseudoknot structures, tRNA.	
10.	Nucleic acid structure	5
10.1	DNA and RNA helical geometrics (A-Z), banding, deformation triplexes, quadruplexes, DNA unusual secondary structure (structure type helical DNA, triplexes, quadruplexes)	
11.	Nucleic acid analysis. DNA and RNA sequencing, determination of modified nucleotides. Analysis of nucleic acid secondary structure	4
12.	RNA catalysis	3
12.1	Chemistry and structure of ribozymes.	
12.2	Evolutionary implications.	
13.	Enzyme mechanisms	8
13.1	Principles of enzyme catalysis.	
13.2	Proteases and polymerases, other examples.	
13.3	Coenzymes and Cofactors.	
14.	Inborn errors of metabolism:Galatosemia, Phenyl ketonurea, Alkaptonuria, Gaucher's disease, Lesh-nyhan syndrome	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.

PAPER VI: BIOSTATISTICS AND POPULATION GENETICS

Duration: 3 Hours

Max. Marks: 100

Periods : 80

Unit I: Quantitative Biology

1. Basic Mathematics for Biologists 8
 - 1.1 Matrices and vectors.
 - 1.2 Exponential functions.
 - 1.3 Periodic functions.
 - 1.4 Different equations, integration.
2. Principles and practice of statistical methods in biological research, samples and populations. 10
 - 2.1 Basic statistics-Arithmetic, Harmonic, Median, Mode, Mean deviation
 - 2.2 Statistics of dispersion, coefficient of variation.
 - 2.3 Standard error; Confidence limits.
 - 2.4 Probability distributions (Binomial, Poisson and Normal).
 - 2.5 Tests of statistical significance.(Student's T -test, Z -test), χ^2 - test
 - 2.6 Testing of Hypothesis
 - 2.6 Correlation and regression.
 - 2.7 Analysis of Variance(One way and Two way ANOVA)

Unit II: Population Genetics

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 distabilizing 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.
5. Genetics of specifications 10
 - 5.1 Phylogenetic and biological concept of species.
 - 5.2 Patterns and mechanisms of reproductive isolation.
 - 5.3 Modes of specification (allopatric, sympatric, pripatric).
6. Molecular Evolution 10
 - 6.1 Gene evolution.
 - 6.2 Evolution of gene families, molecular drive.
 - 6.3 Assessment of molecular drive.
 - 6.4 Micro-and macro-evolution.

7. Molecular phylogenetics 12
- 7.1 Construction of phylogenetic trees.
 - 7.2 Phylogenetic inference-distance methods, parsimony methods, maximum likelihood method.
 - 7.3 Immunological techniques.
 - 7.4 Amino acid sequence and phylogeny.
 - 7.5 Nucleic acid phylogeny-DNA-DNA hybridizations, restriction enzyme sites, nucleotide sequence comparisons and homologies.
 - 7.6 Molecular clocks.

Recommended Books (Quantative Biology)

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

Recommended Books (Population Genetics)

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

University of Rajasthan

M.Sc. (Previous) Zoology

PRACTICAL EXERCISES

I. 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.

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

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

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* sections 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*, *Zoea*, *Mysis*, *Megalopa* *Phyllosoma*, *Veliger*, *Glochidium*, *Bipinnaria*, *Ophiopluteus*, *Echinopluteus*, *Auricularia*, *Tornaria*.

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

V. Physiology:

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

VI. Cell & Molecular Biology & Biotechnology:

- (i) Squash and smear preparations of testis of cockroach and grasshopper, acetoorecin, Fuelgen and Giemsa staining of these preparations.
- (ii) Study of mitosis in onion root tip.
- (iii) Study of giant chromosomes in the salivary gland of Chironomus or Drosophila larva.
- (iv) Vital and supravital staining (with Neutral Red and Janus Green B) of cells of the testis of any insect or mammal to study the mitochondria.
- (v) Chromosome study in cells of the testis of an insect or mammal or cells of the bone marrow of a mammal.
- (vi) Paper chromatography: Unidimensional chromatography, using amino acids from purified samples and biological materials.
- (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.

VII. Population Genetics:

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

VIII. Statistical Methods in Biology:

- (i) Preparation of frequency tables and graphs/line diagrams/bar diagrams / histogram / Pie charts.
- (ii) Exercises on arithmetic 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 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.

OBSERVATIONAL AND FIELD STUDIES

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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M.Sc. (Previous) Zoology

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. Anatomy | |
| a. Major | 10 |
| b. Minor | 6 |
| 2. Population Genetics | 10 |
| 3. Cell & Molecular Biology & Biotechnology | 10+10 |
| 4. Spotting No. 1 – 8 | 24 |
| 5. Record | 10 |
| 6. Viva-voce | 10 |
| 7. Seminar | 10 |

Total = 100


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II Day (IV, V, & VI Papers)

Time: 5 hrs.

Max Marks: 100


Marks

1. Gen. Physiology	20
2. Biochemistry	20
3. Biostatistics	15
4. Spotting (1 to 5)	15
5. Practical Record	10
6. Viva-voce	10
7. Seminar	10

Total = 100

Notes:

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.**


University of
1972

1. M.Sc. (Zoology) FINAL

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 , SEMINAR

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.
 - 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.

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(19)

- 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.
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. Barbour T. Houghton : Reptiles and Amphibians : Their Habitats and Adaptations, Milfin Co, New York.

5. Barrington, E.J.W. ; The Biology of Hemichordata and Protochordata, Olter and Boyd, Edinbourgh.
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 understanding of the Brain, McGraw Hill Company, New York.
12. Joysey, K.A. and Kemp, T.S. : Evolution, Oliver and Boyd, Edinbourgh.
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 Intrductin 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.
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
 - 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 .
- 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.
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.

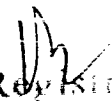
PAPER III: GENES AND DIFFERENTIATION

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. | |


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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
12.1	Stem 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.
 - 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 *in vivo* and *in vitro* assays.
2. Principles of cytological and cytochemical techniques 5
 - 2.1 Fixation, chemical basis of fixation by formaldehyde, glutaraldehyde, 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
 - 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 Cyropreservations 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*.

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*, *Marsupius*, 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. Ammocoete 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.

VI. Environment Biology

- (i) Analysis of pond / stagnant water for : pH, Acidity, Alkalinity, Dissolved oxygen, CO₂, Salinity, Phosphates, COD and BOD.

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- (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, 21hrs, 24 hrs, 28hrs, 33hrs, 38 hrs, 48hrs, 70hrs 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.**

Scheme of Practical Examination

Duration: 5 hrs.

Max. Marks: 100


Exercise	Marks
1. Anatomy	
a. Major	12
b. Minor	8
2. Ethology	5
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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1. CANCER BIOLOGY

PAPER-V: NATURE OF CANCER

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Introduction: Cancer as a cellular disease.
 - 1.1 Historical perspectives.
 - 1.2 Cancer causation.
 - 1.3 Cancer treatment.
 - 1.4 Death due to cancer.
2. Occurrence of cancer
 - 2.1 Present day status of cancer in India.
 - 2.2 Status of cancer occurrence in different parts of the world.
 - 2.3 Cancer of different sex and age group.
3. Tumor classification.
 - 3.1 Benign and malignant tumors.
 - 3.2 Sarcoma and carcinoma.
 - 3.3 Leukemia and lymphoma.
 - 3.4 Ascites tumors.
 - 3.5 Teratocarcinoma.
4. Etiology of cancer
 - 4.1 Staging and grading of cancer.
 - 4.2 *In vitro* cell transformation.
 - 4.3 Apoptosis.
5. Cancer cell
 - 5.1 Structural and ultrastructural profiles.
 - 5.2 Biochemical properties.
 - 5.3 Behavioural properties.
6. Genetic basis of cancer
 - 6.1 Basic concepts of cancer genetics.
 - 6.2 Relationship between cancer incidence and age.
 - 6.3 Cellular and genetic basis of cancer.
 - 6.4 Types of genetic risk factors for cancer.
 - 6.5 Chromosomal abnormalities in tumor.
 - 6.6 Heritable cancer and tumor suppressors.

7. Cancer cell growth patterns and cell kinetics
 - 7.1 Tumor growth.
 - 7.2 Cell cycle.
 - 7.3 Cell proliferation in tumor tissue.
 - 7.4 Experimental tumors.
 - 7.5 Human tumors.
 - 7.6 Cell proliferation, prognosis and therapies.
8. Metastasis
 - 8.1 Introduction.
 - 8.2 Metastatic process.
 - 8.3 Metastatic ability of tumor cell population.
 - 8.4 Properties of metastatic cells.
 - 8.5 Genetic basis of metastasis.


PAPER-VI: CAUSATION, PREVENTION AND CURE OF CANCER

Duration : 3 Hours

Max. Marks – 100

Periods : 90


1. Introduction:
 - 1.1 Historical aspects.
 - 1.2 Environmental factors and cancer.
 - 1.2.1 Tobacco, Alcohol, diets, occupational exposures, hormones and other exposure.
 - 1.3 Specific types of cancer: Hepatocellular carcinoma, Melanoma, Breast cancer, lung cancer, gynaecological cancers, Prostate cancers, Oral cancers.
2. Causation of cancer
 - 2.1 Hereditary cancer.
 - 2.1.1 Introduction.
 - 2.1.2 Xeroderma pigmentosum.
 - 2.1.3 Fanconis anaemia.
 - 2.1.4 Bloom syndrome.
 - 2.1.5 Ataxia telangiectasia.
 - 2.1.6 Retinoblastoma.
 - 2.2 Virus and cancer.
 - 2.2.1 Introduction.
 - 2.2.2 Viruses and oncogenes.
 - 2.2.3 Historical perspectives.
 - 2.2.4 Tumor virus and human cancer.


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- 2.2.5 Retrovirus.
- 2.2.6 DNA tumor viruses.
- 2.3 Chemical carcinogenesis.
 - 2.3.1 Introduction.
 - 2.3.2 Biological characteristics of chemical carcinogenesis.
 - 2.3.3 Initiation, promotion and progression of carcinogenesis.
 - 2.3.4 Assay methods for chemical carcinogens.
 - 2.3.5 Chemical carcinogens in human cancer causation.
- 2.4 Radiation carcinogenesis
 - 2.4.1 Cell transformation.
 - 2.4.2 Mechanism of radiation cell transformation.
 - 2.4.3 Radiation carcinogenesis in animals.
 - 2.4.4 Human data on radiation carcinogenesis.
- 2.5 Hormones and cancer.
 - 2.5.1 Introduction.
 - 2.5.2 Hormone production by tumors.
 - 2.5.3 Hormone and cancer causation.
 - 2.5.4 Hormones and cancer treatment.
- 3. Nutrition and Cancer
 - 3.1 Cancer risks form naturally occurring carcinogens in food, food contaminants, additives.
 - 3.2 Micronutrients in diet: Protein, carbohydrate, fat, fibers.
 - 3.3 Micronutrients in diet: Mineral, salts, green yellow vegetables, fruits.
- 4. Therapy of cancer
 - 4.1 Surgical removal.
 - 4.2 Chemotherapy
 - 4.3 Radiotherapy.
 - 4.4 Immunotherapy.
 - 4.5 Hyperthermia.
 - 4.6 Management of therapies of cancer.
- 5. Prevention of cancer.
 - 5.1 Primary prevention: Education, motivation and legislation.
 - 5.2 Secondary prevention.
 - 5.2.1 Detection of precancerous and early cancerous lesions in body.
 - 5.2.2 Chemoprevention.
- 6. Oncogenes
 - 6.1 Introduction

1.3.5 Fluidity of biomembranes.

1.3.6 Cell Junctions (Gap, tight and desmosomes etc.)


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6.2 Detection of oncogenes in human cancer cells.

6.3 Activation of oncogenes.

6.4 Antioncogenes.

CANCER BIOLOGY

Duration : 5 Hours

Max. Marks – 100

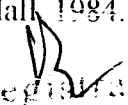
Scheme of practical Examination and Distribution of the marks:

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

Note: It should be ensured that animals used in the practical exercises are not covered under the Wildlife Act 1972 and amendments made subsequently.

Recommended Books

1. Advanced Medical Radiation Dosimetry. Rajan O. Prentice-Hall of India Pvt. Ltd. New Delhi, 1992.
2. Applied Radiobiology of Radiation Protection. Granien, R., Prentice Hall, 1990.
3. Basic Radiation Biology. Pizzarello D.J., Witcofsli Lea R. L. and Febiger: Philadelphia, 1970 or Later.
4. Biological Aspects of Human Irradiation Eds. Pant, G. S. and Basu, AK. Himalaya Publishing House, Delhi, 1992.
5. Biological Assessment of occupational Exposure to Actinides. G. B. Gendcs, H. Mctives and J. Stathes: Nuclear Tech. Pub. Kent, 1989.
6. Biological Effects of Radiation. Coggle. J.E. : Taylor and francis Ltd., London, 1988 or Later Edition.
7. Biological Effects of Radiations. Grosel, D. S. and Hop Zwood, L.E. Academic Press, New York, 2nd Edition, 1979 or Later Edition.
8. Biological Radiation effects. Kiefer, J. Springer-Venlag, Berlin, 1989.
9. Cellular Radiobiology. Lawrence c.w. Arnold, London, 1971 or Later Edition.
10. Developmental Effects of Prenatal Irradiation. Kriegel, H.. VCH,. 1982.
11. Elements of Radiobiology, Seiwan J. Thomas, C. C. 1983.
12. Environment and Human Risks of Tritium, Gesben, G., C. M. Menaene and H. Smilts: Nuclear Tech. Pub. Kent, 1986.
13. Essential of Radiation Biology and Protection, Steve Forshie: Publisher: Delmar Cengage Learning.
14. Frontiers of Radiation Biology Riklin, E. ed. VCH, 1990.
15. Health Effects of Low Level Radiation, Hendec w. R. : Prentice Hall, 1984.


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2. Transport across cell membrane

- 2.1 Diffusion of small molecules.
- 2.2 Osmosis and water channels.
- 2.3 Uniporter-catalyzed transport, Difference between uniport catalyzed transport and passive diffusion. GLUT-1 transport and its kinetics.
- 2.4 Intracellular ion environment and membrane electric potential.
- 2.5 Active transport. P-class ion pumps. F-class and V-class ion pumps and ABC superfamily. Plasma membrane Ca_2^+ ATPase pump. Muscle Ca_2^+ ATPase pump and Na^+/K^+ ATPase pump.
- 2.6 Cotransport by symporters and antiporters.
- 2.7 Transport across epithelia.

3. Cytoskeleton

3.1 Microfilaments

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

3.2 Microtubules

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

3.3 Microtubules and mitosis

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

- 3.4 Kinesin and Dynein.
- 3.5 Cell movements:
- Intracellular transport: Role of kinesin and dynein, microtubule tracks and intracellular membrane vesicles.
 - Amoeboid movements.
 - Second messengers and signal transduction pathway for coordination of migration of cells.
4. **Cilia and Flagella**
- 4.1 Structure and movements
- Sliding of outer doublet.
 - Dynein sliding forces in axonemes.
 - Dynein and axonemal bending.
 - Dynein regulatory complex.
5. **Cell-Cell Signalling**
- 5.1 Endocrine, paracrine and autocrine signaling.
- 5.2 Receptor proteins: Cell surface receptors and intracellular receptors.
- 5.3 Cell surface receptors: G-protein coupled receptors, ion channel receptors, tyrosine kinase-linked receptors and receptors with intrinsic enzymatic activity.
- 5.4 Second messenger System - cAMP and IP₃DAG.
- 5.5 MAP kinase pathways.
- 5.6 Signaling from plasma membrane to nucleus (a) CREB links cAMP signals to transcription (b) MAP kinase.
6. **Signal - Mediated transport through Nuclear Pore**
- 6.1 Nuclear pore complex
- 6.2 Nuclear exports signals and transport of cargo proteins from nucleus to cytosol.
- 6.3 Nuclear localization signals and transport of cargo proteins from cytoplasm to nucleus.
- 6.3 Nuclear localization signals and transport of cargo proteins from cytoplasm to nucleus.
7. **Cell-Cell adhesion and communication**
- 7.1 Cadherin mediated Ca₂⁺ dependent homophilic cell-cell adhesion.
- 7.2 N-CAMs mediate Ca₂⁺ independent homophilic cell-cell adhesion.
- 7.3 Cadherin containing junctions connect cells.
- 7.4 Gap junctions and connexion.
8. **Cell matrix adhesion**
- 8.1 Integrins : in cell matrix and cell-cell interaction.
- 8.2 Integrin and cell to substratum attachment.
- 8.3 Collagen basic structure and assembly.

- 8.4 Non-collagen components of extracellular matrix (Laminin, fibronectin and cell surface proteoglycans)
- 8.5 Plant cell wall.
- 8.6 Auxin and cell expansion.
- 8.7 Cellulose fibril synthesis and orientation.
- 8.8 Plasmodesmata.
- 9. **Cell Cycle**
 - 9.1 Bacterial cell cycle (Helmstetier – Cooper or I+C+D model).
 - 9.2 Partition and cytokinesis.
 - 9.3 Eukaryotic cell cycle – G1, S, G2 and M phases.
 - 9.4 Cell cycle and check points.
 - 9.5 Molecular basis of cell cycle regulation.
 - (a) Cyclins and cyclin – dependent kinases.
 - (b) Regulation of CDK cyclin activity.
- 10. **Cancer**
 - 10.1 Tumor cells and onset of cancer.
 - 10.2 Proto-oncogenesis and tumor suppressor genes.
 - 10.3 Mutation causing loss of cell cycle.
 - 10.4 Mutations affecting genome stability.
- 11. **Aging: The biology of senescence**
 - 11.1 Maximum life span and life expectancy.
 - 11.2 Causes of aging
 - (a) General wear and tear and genetic instability.
 - (b) Free radicals, oxidative damage and antioxidants.
 - (c) Telomerases and aging.
- 12. **Cell Death**
 - 12.1 Apoptosis and necrosis.
 - 12.2 Apoptosis-its characteristics.
 - 12.3 Genes involved in apoptosis.
 - 12.4 Identification of apoptosis.
- 13. **Molecular structure of genes and chromosomes**
 - 13.1 Molecular definition of gene.
 - 13.2 Chromosomal organization of genes and non-coding DNA.
 - 13.3 Mobile DNA.
 - 13.4 Functional rearrangements in chromosomal DNA.
 - 13.5 Organizing cellular DNA into chromosomes.
 - 13.6 Morphological and functional elements of eukaryotic chromosomes.

- 14. **Genetic analysis in cell biology**
 - 14.1 Mutation: Type and causes.
 - 14.2 Isolation and analysis of mutants.
 - 14.3 Genetic mapping of mutations.
 - 14.4 Molecular cloning of genes defined by mutations.
 - 14.5 Gene replacement and transgenic animals.
- 15. **Regulation of Gene Expression**
 - 15.1 Operon concept.
 - 15.2 Catabolic repression.
 - 15.3 Positive and Negative regulation.
 - 15.4 Inducers and corepressors.
 - 15.5 Regulation by attenuation: his and trp operons.
- 16. **DNA binding proteins and gene regulation**
 - 16.1 DNA binding domains.
 - 16.2 Homeodomain proteins.
 - 16.3 Zinc finger proteins.
 - 16.4 Winged-helix (Forked head) proteins.
 - 16.5 Leucine-Zipper proteins.
 - 16.6 Helix Loop-helix proteins.
- 17. **Protein sorting: Organelle biogenesis and protein synthesis.**
 - 17.1 Synthesis and targeting of mitochondrial and chloroplast proteins.
 - 17.2 Synthesis and targeting of peroxisomal proteins.
 - 17.3 Secretory pathways.
 - 17.4 Translocation of secretory proteins across the ER membrane.
 - 17.5 Insertion of membrane proteins in the ER membrane.
 - 17.6 Post-translation modifications in rER.
 - 17.7 Protein glycosylation in ER and Golgi complex.
 - 17.8 Golgi and Post-Golgi protein sorting and proteolytic processing.
 - 17.9 Receptor-mediated endocytosis and sorting of internalized proteins.
 - 17.10 Molecular mechanisms of vesicular traffic.

CELL AND MOLECULAR BIOLOGY

Paper - VI


Duration : 3 Hours

Max. Marks – 100

Periods : 90

- 1.1 Discovery of humoral and cellular immunity.
- 1.2 Early theory of immunity.
- 1.3 Components of immunity.
- 1.4 Innate (nonspecific) immunity.
 - 1.4.1 Anatomic barrier.
 - 1.4.2 Physiologic barriers
 - 1.4.3 Phagocytic barriers.
 - 1.4.4 Inflammatory barriers.
 - 1.4.5 Collaboratin between innate and adaptive immunity.
- 1.5 Adaptive (specific) immunity.
 - 1.5.1 Cell of the immune system (B-lymphocytes, T-lymphocytes and Antigen presenting cells.).
 - 1.5.2 Functions of humoral and cell-mediated immune responses.
 - 1.5.3 Recognition of antigen by B-and T-lymphocytes.
 - 1.5.4 Generation of lymphocyte specificity and diversities.
 - 1.5.5 Role of MHC.
 - 1.5.6 Processing and presentation of antigen.
 - 1.5.7 Clonal selection of lymphocytes.
 - 1.5.8 Cellular interactions required for generatin of immune responses:
 - a. Activation and proliferation of T-Helper cells
 - b. Generation of Humoral immune response
 - c. Generation of CMI
2. Cells and organs of immune system
 - 2.1 Hematopeisis
 - 2.1.1 B-Lymphocytes, T-lymphocytes, Null cells.
 - 2.1.2 Mononuclear cells phagocytes (antimicrobial and cytotoxic activities: antigen processing and presentation, secretion of factors).
 - 2.1.3 Granulocytic cells (Neutrophils, Eosinophils and Basophils).
 - 2.1.4 Mast cells.
 - 2.1.5 Dendritic cells.
 - 2.2 Organs of immune system.
 - 2.2.1 Primary lymphoid organs (Thymus, bone marrow).

- 2.2.2 Secondary lymphoid organs (Lymph nodes, spleen, mucosal associated lymphoid tissue, cutaneous associated lymphoid tissue)..
- 2.2.3 Lymphatic system
- 3. Antigens
 - 3.1 Immunogenicity versus antigenicity.
 - 3.2 Factors that influence immunogenicity.
 - 3.2.1 Contribution of the immunogens (foreignness, molecular size, chemical composition and heterogeneity, susceptibility to antigen processing and presentation).
 - 3.2.2 Contribution of biological system. (genotype of the recipient animal, immunogen dosage and route of administration, adjuvant).
 - 3.2.3 Haptens.
- 4. Immunoglobulins: Structure and function
 - 4.1 Molecular structure of Ig, Light chain and Heavy chain.
 - 4.2 Immunoglobulin domains.
 - 4.2.1 Variable region domains (CDRs and antigen binding, conformational changes included by antigen binding)
 - 4.2.2 Constant region (CH and CL domains, hinge region and other constant region domains).
 - 4.3 Immunoglobulin classes: IgG, IgM, IgA, IgE and IgD and their biological activities.
 - 4.4 Immunoglobulin mediated effectors functions (Opsonization activation of complement, antibody dependent cell mediated cytotoxicity).
 - 4.5 Antigenetic determinants on immunoglobulin (isotype, allotype and idiotype).
 - 4.6 Monoclonal antibodies.
 - 4.6.1 Formation and selection of hybrid cells.
 - 4.6.2 Production of monoclonal antibodies.
 - 4.6.3 Clinical uses of monoclonal antibodies.
 - 4.6.4 Catalytic monoclonal antibodies (enzymes).
- 5. Organization and expression of Ig genes
 - 5.1 Genetic model compatible with Ig structure.
 - 5.1.1 Germ line and somatic variation models.
 - 5.1.2 Two gene model of Dryer and Bennett.
 - 5.1.3 Verification of Dryer and Bennett hypothesis.
 - 5.2 Multigene organization of Ig genes.
 - 5.2.1 I-chain multigene family
 - 5.2.2 K-chain multigene family.
 - 5.2.3 Heavy chain multigene family.
 - 5.3 Variable region gene rearrangement.


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- 5.3.1 V-J rearrangements in light chain DNA.
- 5.3.2 V-D-J rearrangements in heavy chain DNA.
- 5.4 Mechanism of variable region DNA rearrangement.
 - 5.4.1 Recombination signal sequences.
 - 5.4.2 Enzymatic joining of gene segments.
 - 5.4.3 Identification of Raf-1 and Raf-2 genes.
 - 5.4.4 Defects in Ig gene rearrangements.
 - 5.4.5 Productive and non-productive arrangement.
 - 5.4.6 Allelic exclusions.
- 5.5 Generation and antibody diversity.
 - 5.5.1 Multiple germ line V,D and J gene segments.
 - 5.5.2 Combinatorial V-J and V-D-J joining.
 - 5.5.3 Junctional flexibility.
 - 5.5.4 P-addition and N-addition.
 - 5.5.5 Association of heavy and light chain.
- 5.6 Class switching among constant region genes.
 - 5.6.1 Expression of Ig genes.
 - a. Differential RNA processing of heavy chain primary transcripts.
 - b. Expression of membrane of secreted Ig.
 - c. Simultaneous, assembly and secretion of IgM and IgD.
 - d. Synthesis, assembly and secretion of Ig.
 - 5.6.2 Regulation of Ig gene transcription.
 - a. Effect of DNA rearrangement of transcription
 - b. Inhibition of Ig-gene expression in T-cells.
 - 5.6.3 Antibody genes and antibody engineering.
 - a. Chimeric and hybrid monoclonal antibodies.
 - b. Monoclonal antibodies constituted from Ig gene libraries.
- 6. Antigen-Antibody Interaction
 - 6.1 Antibody affinity and avidity
 - 6.2 Cross reactivity.
 - 6.3 Aggultination reactions.
 - 6.4 Precipitation reaction.
 - 6.5 Complement pathways (Classical,Alternative and Lectin) and complement fixation test.
- 7. Major histocompatibility complex.
 - 7.1 General organization and inheritance of MHC.
 - 7.1.1 Location and function of MHC regions.

- 7.1.2 MHC haplotypes.
- 7.1.3 Congenic MHC mouse strains.
- 7.2 MHC molecules and genes.
 - 7.2.1 Structure of class I molecules.
 - 7.2.2 Structure of class II molecules.
 - 7.2.3 Organization of class I and Li genes.
 - 7.2.4 Peptide binding by MHC molecules.
 - 7.2.5 Class III molecules.
- 7.3 Genomic maps of MHC genes.
 - 7.3.1 Maps of class I MHC.
 - 7.3.2 Maps of class II MHC.
 - 7.3.3 Maps of class III MHC.
- 7.4 Cellular distribution of MHC molecules.
- 7.5 Regulation of MHC expression.
- 7.6 MHC and immune responsiveness.
- 7.7 MHC and diseases susceptibility.
- 8. Antigen Processing and Presentation
 - 8.1 Role of antigen presenting cell.
 - 8.1.1 Early evidence for the necessity of antigen processing.
 - 8.1.2 Cells that function in antigen presentation
 - 8.2 Evidence for two processing and presentation pathways.
 - 8.2.1 Endogenous antigens. The cytosolic pathways.
 - a. Peptide generation by proteosomes.
 - b. Peptide transport from the cytosol to RER.
 - c. Assembly of peptide with class I MHC molecules.
 - 8.2.2 Exogenous antigens: The endocytic pathway.
 - a. Peptide generation in endocytic vesicles.
 - b. Transport of class II MHC molecules to endocytic vesicles.
 - c. Assembly of peptide with class II MHC molecules.
 - 8.3 Presentation of non-peptide bacterial antigens.
- 9. Cytokines
 - 9.1 Properties of cytokines.
 - 9.2 General structure of cytokines.
 - 9.3 Function of cytokines.
 - 9.4 Cytokines related diseases.
 - 9.4.1 Bacterial septic shock.


- 9.4.2 Bacterial toxic shock and similar diseases.
- 9.4.3 Lymphoid and myeloid cancers
- 9.4.4 Chagas diseases.
- 10 Immune system in health and diseases
 - 10.1 Immune response to infectious diseases.
 - 10.1.1 Viral infections.
 - a. Viral neutralization by humoral antibody.
 - b. Cell mediated antiviral mechanism.
 - c. Viral evasion of host defence mechanisms.
 - 10.1.2 Bacterial infections.
 - a. Immune responses to extra-cellular and intracellular bacteria.
 - b. Bacterial evasion of host defense mechanism.
 - 10.1.3 Protozoa and diseases.
 - 10.1.4 Diseases caused by helminthes.
- 11. Vaccine
 - 11.1 Active and passive immunization.
 - 11.2 Designing vaccines for active immunization.
 - 11.3 Whole organism vaccine.
 - 11.3.1 Attenuated viral or bacterial vaccines.
 - 11.3.2 Inactivated viral or bacterial vaccines.
 - 11.4 Polysaccharide vaccines.
 - 11.5 Recombinant vector vaccines.
 - 11.6 DNA vaccines.
 - 11.7 Synthetic peptide vaccines.
 - 11.8 Multivalent peptide vaccines.
- 12. AIDS and other immune-deficiencies.
- 13. Autoimmunity
 - 13.1 Organ specific autoimmune diseases.
 - 13.2 Systemic autoimmune diseases.
 - 13.3 Proposed mechanisms for induction of autoimmunity.
- 14. Cancer and immune system
- 15. Transplantation immunology
- 16. Cellular energetics
 - 16.1 Electron transport and oxidative phosphorylation.
 - 16.1.1 Proton motive force.
 - 16.1.2 Electron flow.

- 16.1.3 Shutting of electrons between FFC.
- 16.1.4 Reduction potentials of electron carriers.
- 16.1.5 Pumping protons out of the mitochondrial matrix.
- 16.1.6 ATP syntheses.
 - a. $F_0 F_1$ complex and proton motive force.
 - b. Inner mitochondrial membrane transporters and proton motive force.
 - c. Regulation of mitochondrial oxidation rate.
- 16.1.7 Chemiosmotic mechanism of ATP formation and related experiments.
- 16.2 Photosynthesis.
 - 16.2.1 Photosynthesis and thylakoid membrane.
 - 16.2.2 Stages of Photosynthesis.
 - 16.2.3 Light absorption and charge separation across thylakoid membrane.
 - 16.2.4 Molecular analysis of photosynthesis.
 - 16.2.5 CO_2 metabolism during photosynthesis

CELL & MOLECULAR BIOLOGY


LIST OF PRACTICALS

1. Operation of various microscopes
 - 1.1 Use of phase contrast.
 - 1.2 Use of fluorescence microscope - nucleic acid by Acridine orange/ Ethidium bromide.
 - 1.3 Use of transmission electron microscope.
 - 1.4 Use of oculometer: Standardization and measurements of cell height, nuclear diameters and tabular diameters.
 - 1.5 Use of ocular grid-standardization and counting of cells or nuclei in cross section or epithelium.
2. Preparation of biological tissues and sectioning for:
 - 2.1 Paraffin wax histology by microtome.
 - 2.2 Fresh frozen sections by cryostat.
 - 2.3 Ultrathin sections by ultratome.
3. Cytochemistry
 - 3.1 Carbohydrate (a) PAS method (b) Alcian blue method.
 - 3.2 Proteins (a) Mercury bromophenol blue method (b) Ninhydrin method.
 - 3.3 Lipids (a) Phosphomolybic acid method (b) Copper phthalocynin method.
 - 3.4 Nucleic acid (a) Feulgen method (b) Methyl green- Pyronil method.
4. Biochemical methods
 - 4.1 Determination of pK value of buffer.
 - 4.2 Determination of absorption maximum of a solution.


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- 4.3 Determination of relationship between absorption and various concentration of a solution using a colorimeter spectro colorimeter/spectrophotometer.
- 4.4 Preparation of standard curve for proteins, lipids, carbohydrates and enzymes.
- 4.5 Determination of optimum concentration of enzyme for kinetic studies.
- 4.6 Determination of Michaelis - Menten (KM) and Vmax for an enzyme by Thumer's method.
- 4.7 Quantification of enzymes
 - 4.7.1 By end point techniques as exemplified by alkaline and acid phosphatase.
 - 4.7.2 By substrate – left over technique as exemplified by LDH.
 - 4.7.3 By turn over number as exemplified by GST.
5. Fractionation
 - 5.1 Tissue homogenization and fractionation by differential centrifugation for isolation of mitochondria, nuclei and cytosol and use of marker enzymes for assessment of the components.
 - 5.2 Fractionation of protein, RNA and DNA and their Quantification.
6. Separation techniques
 - 6.1 Separation of proteins and DNA by agarose electrophoresis.
 - 6.2 Separation of proteins and iso-enzymes, on SDS-PAGE and PAGE.
 - 6.3 Electro-eluting of proteins DNA/RNA from electrophoretic gels.
 - 6.4 Separation of amino acids by paper chromatography.
 - 6.5 Separation of phospholipids by TLC.
 - 6.6 Separation of haemoglobin by column chromatography.
7. Chromosomal techniques
 - 7.1 Preparation of salivary gland chromosomes from Drosophila and Chironomid larva and stain with acetocarmine/aceto-orcein / Feulgen.
 - 7.2 Preparation of mammalian chromosomes from bone marrow/ testis and stain with Giemsa stain.
8. Immunization techniques
 - 8.1 Emulsification with Freund's reagent.
 - 8.1.1 Preparation of emulsions with syringe method.
 - 8.1.2 Preparation of emulsion with double- hubbed needle method.
 - 8.2 Testing type of emulsion.
 - 8.3 Absorption of soluble proteins on insoluble colloidal carrier.
 - 8.3.1 Alum precipitates.
 - 8.3.2 Alum hydroxide adjuvants.
9. Immunization route.
 - 9.1 Intradermal
 - 9.2 Subcutaneous.


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- 9.3 Intramuscular.
- 9.4 Intraperitoneal.
- 9.5 Intravenous.
- 9.6 Foot pad.
10. Bleeding schedules and collection of blood
 - 10.1 Bleeding from ear.
 - 10.2 Retro-orbital.
 - 10.3 Cardiac puncture.
 - 10.4 Branchial vein.
 - 10.5 From external jugular vein.
11. Separation and preservation of serum
 - 11.1 Liquid storage.
 - 11.1.1 Using preservative.
 - 11.1.2 Sterilization.
 - 11.2 By freezing.
 - 11.3 By lyophilisation.
12. Isolation of T and B cells from sensitized animals
 - 12.1 From spleen.
 - 12.2 From lymph nodes.
 - 12.3 From human blood-rosette formation with sheep RBC.
13. Purification of antibodies and antigens
 - 13.1 Insolubilization of antibodies and antigenic proteins using glutaraldehydes.
 - 13.2 Immuno-adsorption.
 - 13.3 Dissociation of absorbed material from immune-adsorbents.
14. Quantitation of antibodies
 - 14.1 Precipitation techniques.
 - 14.2 Immuno-diffusion method.
 - 14.3 Immuno-electrophoresis method.
15. Immunoassays: RIA, ELISA
16. Permanent slides (for spotting): Thymus, lymph nodes, spleen, bone marrow, types of cells (squamous, cuboidal, columnar epithelial cells, blood cells, nerve cells, muscle cells, connective tissues of various types, adipose tissues, mitotic & meiotic chromosomes and their different phases cancer cells of various types etc.)

Note : 1. Slides to be submitted from each exercise .

- 2. It should be ensured that animals used in the practical exercises are not covered under the Wildlife Act 1972 and amendments made subsequently.**


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SCHEME OF PRACTICAL EXAMINATION

Duration : 5 Hours

Max. Marks – 100

1. Exercise on Microtomy Sectioning	10
2. Exercise on Cytochemistry	12
3. Exercise on biochemical estimation	12
4. Exercise on Differential centrifugation/chromatography/electrophoresis	10
5. Exercise on immunology	10
6. Exercise on chromosomal preparation	10
7. Identification and comments (Spots-Eight, 2 marks each)	16
8. Viva-voce	10
9. Record+ submission of slides prepared	(7+3)=10
	Total = <u>100</u>

CELL & MOLECULAR BIOLOGY

Recommended Books:

1. Abbas. A.K. Lichtman, A.R. and Pakes, J.S. Molecular Immunology, W.B. Saunders & Col., London
2. Adams RLP, Knowler J.T. and Leader D.P. The Biochemistry of the Nucleic Acids. Chapman and Hall, London, 1986.
3. Alkberts B, Bray D, Lewis, J., Raff, M., Roberts, K. and Watson J.D. Molecular Biology of the Cell. Garland Publishing, Inc. New York, 1994.
4. Bolrover S.R. Hyams J.S., Jones S. Shephard E.A. and White H.A. from genes to cells. Wiley-liss, new York, 1997.
5. Cooper, G.M. The cell A molecular approach. ASM Press, Washington DC, 2000.
6. Cruse, J.M. and Lewis, R.E., Atlas of Immunology, CRC Press, New York.
7. Dabje, D.D. Introduction to Practical Molecular Biology, John Wiley & Sons Inc, New York.
8. Darnell, J.L. Lodish, H. and Baltimore, D. Molecular Cell Biology, Scientific American Books Inc. New York.
9. De Robertis E.D.P. and De Robertis Jr., E.M.F., Cell and Molecular Biology. K.. Varghese Cop. Bombay, 1998.
10. Fireerg E.C. Walker G.C. and Siede, W. DNA Repair and Mutagenesis ASM Press Wadlington DC, 1995.
11. Freifelder D. Molecular Biology, Narosa Publishing House, New Delhi, 1997.
12. Gardner, eJ. Simons, M.J. and Snustad, D.P. Principles of Genetics. John wiley & Sons Inc. New York.
13. Gascue, C.E.A. Manual of laboratory experiences in Cell Biology Universal Book Stall, New Delhi.
14. Gerbare J. and Kirschner M. Cells, Embryos and Evolution. Blackwell science, Inc. Massachusetts, 1997.

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15. Glick B.R. and Pasternak I.I. Molecular Biotechnology Principles and Applications of Recombinant DNA. ASM Press, Washington, 1998.
16. Goldsby, R.A. Kindt, T.J. and Osborne, B.A. Kuby Immunology. W.H. Freeman & Co. New York.
17. Grese A.C. Cell Physiology, WB. Saunders Co., Philadelphia, 1979.
18. Karp G. Cell and Molecular Biology. Concepts and experiments. John Wiley and Sons. Inc. New York, 1999.
19. Lodish H., Berk A., Zipursky S.L., Matsudaira P., Baltimore D. and Darnell J. Molecular Cell Biology W.H. Freeman and Company, New York, 2000.
20. Lucent Micklos D.A. and Freyer G.A. DNA science A first course in recombinant DNA Technology. Carolina Biological supply compo and Cold Spring Harbour Laboratory Press, Burlington, North Carolina, 1990B. Genes VII. Oxford University Press, Oxford, 2000.
21. Malacinski G.M. and Freifelder P. Essentials of Molecular Biology Jones and Bartlett Publishers Boston, 1999.
22. Meyers R.A. Molecular Biology and Biotechnology, A comprehensive desk reference. VCH Publishers, Inc., New York, 1995.
23. Micklos D.A. and Freyer G.A. DNA science A first course in recombinant DNA Technology. Carolina Biological supply compo and Cold Spring Harbour Laboratory Press, Burlington, North Carolina, 1990.
24. Old R.W. and Primrose S.B. Principles of Gene Manipulation. An introduction to genetic engineering. Blackwell Scientific Publication London, 1989.
25. Shelve P. and Blanch DEW, Cell and Molecular Biology, John Wiley and Sons Inc., New York, 1994.
26. Talwar, G.P. and Gupta, S.K. A handbook of Practical and clinical Immunology. Vol. I & II. Vikas Publishing House Pvt. Ltd., New Delhi.
27. Twyman R.M. and Wisden W. Advanced Molecular Biology, A Concise Reference Viva Books Pvt. Ltd. New Delhi, 1999.
28. Voet, D. and Voet, J.G. Biochemistry, John Wiley & Sons Inc New York.
29. Walker J.M. and Gingold E.B. Molecular Biology and Biotechnology Purnima Educational Book Agency, New Delhi, 1992.
30. Watson, J.D., Hopkins, N.H. Roberts, J.W. Steitz, J.A. and Weiner A.M. Molecular Biology of the Gene. The Benjamin/comings Pub. Co. Inc. California.
31. Winnacker E.L. from genes to clones Introduction to gene technology, Purnima Education Book Agency, New Delhi. VCH Publishers, New York, 1987.
32. Zubay, G.L. Parson, W.W. and Vance, D.E. Principles of Biochemistry. Wm.C. Brown Publishers, Oxford, England.


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3. DEVELOPMENTAL BIOLOGY


PAPER-V: CONCEPTS OF EMBRYOLOGY

Duration : 3 Hours

Max. Marks – 100

Periods : 90

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


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- 6.12 Parthenogenesis.
- 6.13 Artificial insemination.
- 6.14 Fusion of genetic material in mammals.
- 6.15 Fertilization *in vitro*.
- 6.16 Cultivation and re-implantation and significance of this technique.
- 6.17 Control of human fertility.
- 6.18 Birth control.
- 6.19 Contraception
 - 6.19.1 Natural.
 - 6.19.2 Barrier or mechanical contraceptives.
 - 6.19.3 Method of contraception in human beings.
- 6.20 Artificial insemination in cattle.
- 6.21 Test tube baby, its advantages and disadvantages.
- 6.22 Cryopreservation of human embryos.
- 6.23 Gamete intra-fallopian transfer (GIFT).
- 7. Cleavage:
 - 7.1 Role of nucleus.
 - 7.2 Problem of DNA synthesis; energy requirements; biochemical changes; distribution of morphogenetic substances of egg and their role during cleavages.
 - 7.3 Characteristics and mechanism of cleavages.
- 8. Early embryonic development in selected non-chordates and chordates (with particular reference to the type of eggs; pattern of cleavages; blastulation; gastrulation; establishment of three germ layers and the basic body plan).
 - 8.1.1 Coelenterata
 - 8.1.2 Ctenophora
 - 8.1.3 Platyhelmenthes
 - 8.1.4 Annelida
 - 8.1.5 Mollusca
 - 8.1.6 Echinodermata
 - 8.1.7 Insecta
 - 8.2 Chordates (frog, chick and mammals).
 - 8.3 Determination of embryonic axes and cell lineage in mammalian development.
- 9. Morphogenetic cell movements.
 - 9.1 Dissociation and re-aggregation of cells.
 - 9.2 Selective affinities of cells during development.

10. Fate maps
 - 10.1 Methods of their constructions, utility, comparative topographical relationship of the presumptive areas in early embryos of Anphioxus, Fishes, Amphibian and Birds.
11. Neurulation in Vertebrates
 - 11.1 Mechanism of neural tubes formation.
 - 11.2 Segregation of mesodermal and endodermal organ rudiments.
12. Determination
 - 12.1 Concepts of prospective fates, potencies; progressive determination and differentiation mosaic and regulative eggs-a problem of determination.
13. Restriction of potencies in the germinal layers of amphibians and birds; cytoplasmic determination of germ cells in nematodes, Drosophila and frog.
14. Cell and tissue interactions in development
 - 14.1 Primary embryonic induction.
 - 14.2 Nature and regional specificity of induction.
 - 14.3 Methods of study and analysis of the phenomenon of neural induction.
 - 14.4 Heterogenous inductors
 - 14.5 Chemistry and properties of inducing substances
 - 14.6 Competence
 - 14.7 Mechanism and theories of induction
 - 14.8 Secondary and tertiary inductors
 - 14.8.1 Concept of organizer.
 - 14.8.2 Evocation and individuation.
 - 14.8.3 Trans- determination in insect germinal discs.
 - 14.8.4 Ectodermal and mesodermal interactions in the morphogenesis of limbs in vertebrates.
 - 14.9 The role of apical ridge.
15. Productive interactions in the morphogenesis and differentiation
16. Origin and development of nerve cells and nerve fibres, computer analysis of cellular interactions.
17. Gradients:
 - 17.1 The concepts; Child's hypothesis.
 - 17.2 Metabolic differences in embryonic cell.
 - 17.3 Biochemical gradients in sea-urchin eggs and their morphogenetic importance.
18. Morphogenetic fields
 - 18.1 The concepts; Nature and temporal character of fields.
 - 18.2 Progressive determination within a field.
19. Segmentation of vertebrate embryo.

20. Development of ectodermal organs
 - 20.1 Brain
 - 20.2 Neural crest and its derivatives
 - 20.3 Skin
 - 20.4 Scale and feather
21. Development of mesodermal organs
 - 21.1 Heart
 - 21.2 Kidney
 - 21.3 Gonads
 - 21.4 Reproductive ducts
22. Development of endodermal organs
 - 22.1 Liver
 - 22.2 Pancreas
 - 22.3 Thymus
23. Differentiation
 - 23.1 Definition and biochemical basis of differentiation
 - 23.2 Structural and biochemical changes during differentiation of Muscle Cartilage, Pigment cells, Lens, Fibres, Mammalian erythroid cells, Epidermis
 - 23.3 Concept of stem cells and establishment of tissue specific cell lines
 - 23.4 Cell division and cyto-differentiation
 - 23.5 Stability of differentiated state of cells.
 - 23.6 Chemical control of differentiation.
 - 23.7 Influence of animalizing and vegetalizing agents on sea urchin.
 - 23.8 De-differentiation; modulation and metaplasia.
 - 23.9 Trans-differentiation, influence of hormones on differentiation of tissues and organs.
24. Development of the immune system.
25. Cell, tissue and organ culture
 - 25.1 Basic requirements.
 - 25.2 Design of the laboratory.
 - 25.3 Balanced salt solution.
 - 25.4 Use of antibiotics.
 - 25.5 Culture media.
 - 25.6 Methods of preparation of cell, tissue and organ for cultivation in vitro.
 - 25.7 Contribution of culture studies in developmental biology.

3. DEVELOPMENTAL BIOLOGY


PAPER-VI: GENES AND DEVELOPMENT

Duration : 3 Hours

Max. Marks – 100


Periods : 90

1. Role of cell surface in morphogenesis.
2. Pattern formation.
 - 2.1.1 General and theoretical aspects of pattern formation.
 - 2.1.2 Polarity.
 - 2.1.3 Apical dominance.
 - 2.1.4 Positional information.
 - 2.1.5 Pattern formation in limb development in vertebrates.
 - 2.1.6 Feather pattern in birds and wing pattern in insects.
 - 2.1.7 Importance of retinoic acid in pattern formation in amphibia and birds.
3.
 - 3.1 Nuclear transplantation in amphibians and mammals.
 - 3.2 Cloning.
 - 3.3 Pleuripotency of somatic cells.
4. Role of nucleus and cytoplasm in development.
 - 4.1 Molecular exchange between, cytoplasm and nucleus.
 - 4.2 Nuclear control of morphogenesis.
 - 4.3 Nuclear transplantation between species.
 - 4.4 Prevention of chromosomal diminution in the germ cells of *Ascaris* by cytoplasmic determinants.
5. Genetic interaction in cell differentiation.
6. Genetic control of development.
 - 6.1 At transcriptional level.
 - 6.2 At translational level.
 - 6.3 Post-translational control.
 - 6.4 Epigenetic modification of proteins.
 - 6.5 Determination of embryonic axis.
 - 6.6 Segmentation of larval body.
 - 6.7 Homeotic genes.
7. Function of genes during development transgenic cells and organisms.
8. Gene interactions in development: Gene action, Homeobox.
9. Differential gene function during development.
 - 9.1 Changing patterns of tissue specificity of protein synthesis.


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- 9.2 Embryonic, fetal and adult hemoglobin's.
- 9.3 Differential RNA synthesis.
10. Gene mutations affecting programmed cell death.
11. Homocotic mutations
 - 11.1 Bombyx mori.
 - 11.2 Bithorax locus in Drosophila.
 - 11.3 Antepnapedia locus in Drosophila.
 - 11.4 Relationship of developmental biology with genetics and evolution.
 - 11.5 Ontogeny and phylogeny.
 - 11.6 Morphological recapitulation of phylogeny ontogeny.
 - 11.7 Molecular recapitulation in ontogeny.
 - 11.8 Urea cycle in vertebrate phylogeny and ontogeny.
 - 11.9 Arboreal salamanders and frogs without tadpoles heterochrony and morphological adaption.
 - 11.10 Diversity of modes of reproduction in frogs of temperate and tropical regions.
 - 11.11 Mechanism of amphibian hetro-chrony.
12. Ectodermal mesodermal interactions in the morphogenesis of limb in vertebrate
 - 12.1 The role of apical ridge.
 - 12.2 Specification of the anterior-posterior limb axis.
 - 12.3 Hox genes.
 - 12.4 Polarizing zones.
13. Route of cell death in morphogenesis
 - 13.1 Development of the terapod limb.
 - 13.2 Cell death in formation of digits and joints.
14. Growth
 - 14.1 Dynamics of population growth.
 - 14.2 Isometric and allometric.
 - 14.3 Differential growth.
 - 14.4 Physiological mechanism of growth.
15. Ageing (Senescence)
 - 15.1 Cellular basis of ageing.
 - 15.2 Maximum life span and life expectancy.
 - 15.3 Oxidative damage.
 - 15.4 Mitochondrial genome damage.
 - 15.5 Genetic basis of ageing.
 - 15.6 Telomere shortening.
 - 15.7 Theories of ageing.



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- 15.8 Ageing of cells *in vitro*.
16. Environmental regulation of animal development
- 16.1 Abnormal growth (teratomas).
- 16.2 Teratology-types of abnormalities.
- 16.3 Genetic effects (pleiotropism, phenocopies, canalization and inborn errors in metabolism).
- 16.4 Environmental effects.
- 16.5 Teratogenic agents (drugs, nutritional deficiencies, injections, ionizing radiation).
- 16.6 Retinoic acid as a teratogen.
- 16.7 Alcohol as a teratogen.
- 16.8 General mechanisms and mode of action of teratogen agents.
17. Embryological considerations in teratology.
18. Twinning.
19. Malignancy
- 19.1 General characteristics and properties of cancer cells including structural and metabolic alterations in these cells.
- 19.2 Metaplasia and carcinogenic agents.
20. Embryonic adaptations
- 20.1 Cleidoic eggs.
- 20.2 Development, structure and physiology of extra-embryonic membranes in amniotes.
- 20.3 Development, structure and physiology of placenta in Eutherian mammals.
21. Embryonic nutrition
- 21.1 Yolk utilization by embryos of invertebrates and vertebrates.
- 21.2 Fetal nutrition in mammals.
- 21.3 Placental physiology.
22. Metamorphosis
- 22.1 Larval forms of non-chordates and chordates and their morphological transformation to adult form.
- 22.2 Morphogenetic changes during metamorphosis in insect and their hormonal control.
- 22.3 Morphological, biochemical and physiological changes during metamorphosis in amphibians and their hormonal control.
23. Regeneration
- 23.1 Definition; characteristic of regeneration and its comparison with ontogenetic development.
- 23.2 Distribution of regenerative ability in animal kingdom.
- 23.3 Forms and patterns of regeneration.
- 23.4 Morphollaxis.

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

PRACTICALS: DEVELOPMENTAL BIOLOGY

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


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

Note:

1. * indicates use of softwares.
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.

Scheme of Practical Exam.

4. ENDOCRINOLOGY

PAPER-V: ENDOCRINE GLANDS

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Historical background, scope and status of endocrinology 2
2. Endocrine glands: an overview 1
3. Biochemical nature of hormones 2
4. Mechanism of action of hormones 4
5. Study of the following major endocrine glands of vertebrates:

a)

Pituitary: General, developmental and comparative anatomy; functional cytology of the pituitary gland of mammalian and sub-mammalian vertebrates; adenohypophyseal hormones, their chemistry and physiology, chromatophore regulation among vertebrates; neurohormonal peptides; their chemistry and

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- phyletic distribution: formation, storage, release and transport of neurohypophyseal principles; effects of hypophysectomy. 8
- b) **Thyroid:** General, developmental and comparative anatomy, evolution of thyroidal function, biochemistry, biological action of thyroid hormones and their inter-relationship with other endocrine secretions; effects of thyroidectomy; calcitonin: its chemistry and physiology .
 - c) **Parathyroid :** General, developmental and comparative anatomy, biochemistry and physiology of the parathyroid hormone; effects of para-thyroidectomy 5
 - d) **Pancreas islets:** General, developmental and comparative anatomy; biochemistry and physiology of insulin and glucagon; effects of pancreatotomy. 4
 - e) **Adrenal:** General, developmental and comparative anatomy; chromaffin tissue, biochemistry and physiology to catecholamines; the sympathetic-chromaffin complex; steroidogenic tissue: structure and nomenclature of steroid hormones; biochemistry and physiology of adrenal steroids; effects of adrenalectomy. 8
 - f) **Pineal:** General, developmental and comparative anatomy; biochemistry and physiology of the pineal principles. 4
6. **Female reproductive system:** Comparative anatomy and physiology of the mammalian and sub-mammalian ovary and sex accessory structures, ovarian hormones and their functions. 10
 7. **The male reproductive system:** Comparative anatomy and physiology of the mammalian and sub-mammalian testis, secondary sex accessory structures, testicular hormones and their functions, semen and its biochemistry. 10
 8. **The hypothalamo-hypophyseal-gonadal relationship.** 3
 9. **Biology of spermatozoa and ovum:** Structure, development and function. 4
 10. Endocrinology of fertilization, implantation, delayed implantation, parturition and lactation. 6
 11. Placenta as an endocrine tissue; foeto-placental unit. 4
 12. Hormonal control of sex differentiation and sex determination 4
 13. Assisted reproductive technology (ART). 5

4. ENDOCRINOLOGY


PAPER-VI: REGULATORY ASPECTS

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Vertebrate neuroendocrinology : Ultrastructure and function of the neuro-secretory cell, hypothalamo-hypophyseal relationship, hypothalamus in relation to higher nervous centres, other neurosecretory systems in vertebrates, the urophysis, the subcommissural organ and the pineal complex. 10
2. Invertebrate neuroendocrinology: Anatomy and physiology of the endocrine and neuro-endocrine systems of Annelida, Arthropoda and Mollusca. 10


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

List of Practicals:

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

9. Effects of epinephrine on chromatophores in fish.
10. Study of microscopic slides of endocrine and related structures.

Note:


1. Slides of exercises to be submitted during examination.
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.

**SCHEME OF PRACTICAL EXAMINATION
AND DISTRIBUTION OF MARKS**

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

Recommended Books:

1. Desjardins, C. and Ewing L.L. Cell and Molecular Biology of the testis Oxford University Press, New York, 1993.
2. Gorbman, A. and Bern, H.A. A Text Book of Comparative Endocrinology, John Wiley and Sons Inc., New York, 1962 (Indian Edition- Wilel Eastern Pvt. Ltd., New Delhi, 1974.)
3. Hadley, M.E., Endocrinology. Prentice hall International, Inc. New Jersey, 2000.
4. Joy, K.P. Krishna A. and Haldar C: comparative Endocrinology and Reproduction. Narosa Publishing House, New Delhi, 1999.
5. Levy, A. and Lightman S. Endocrinology. Oxford University Press, Oxford, 1997.
6. Nalbandov, AS.: Reproductive Physiology. W.H. Freeman and Co., New York, 1964. Indian Edition Taraporevala & Sons Pvt. Ltd. Bombay, 1970).
7. Negro-Vilar, A. Isidori A, Paulson J. Abdelmassih R. and Castro, P.P Andrology and Human Reproduction; Raven Press, New York. 1988.
8. Nieschlag E. Habenicht UP. and Nieschlagss. Spermatogenesis Fertilization-Contraception Springer-Verlag, Berlin, 1992.


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9. Nieschlag E. and Behre H.M. Testosterone Action-Deficiency Substitution. Springer-Verlag Berlin, 1996. Scientific Publishers Ltd., 2001.
10. Thomas J.A., Endocrine Methods. Academic Press, New York, 1996.
11. Turner CD.: General Endocrinology, 13: Saunders and Co. Philadelphia, 1974. Toppan Co. Pvt. Ltd., Singapore, 1974.
12. Wilson J.D. and Foster D.W. Williams Text Book of Endocrinology W.B. Saunders Co., Philadelphia, 1992. Burger H. and Dkrestor D. The testis. Raven Press, New York. 1989;

5. ENTOMOLOGY

PAPER-V: MORPHOLOGY AND PHYSIOLOGY

Duration : 3 Hours

Max. Marks – 100

Periods : 90

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


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5. ENTOMOLOGY


PAPER-VI: SYSTEMATICS, ECOLOGY AND APPLIED ENTOMOLOGY

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Classification of insects up to orders and suborders, basis and short history of classification. Introduction to primitive insects.
2. Detailed classification of important and selected super families, and families of the following orders- Orthoptera, Isoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera.
3. Social tire in Isoptera and Hymenoptera.
4. Life cycle of Locusts and Aphids.
5. Origin and Evolution of insects with special reference to fossil insects; causes of success of insects.
6. Ecology of insects
 - (a) Effect of physical factors.
 - (b) Intra and inter- specific relations.
 - (c) Population dynamics.
 - (d) Host-plant insect interactions.
 - (e) Biochemical adaptations of environmental stress (Metamorphosis; Diapause, Polymorphism etc.)
7. Concept of pest. How and why insects have become pests?
8. Life history, damage caused and control of major pests of
 - (a) Cash crop, e.g. sugarcane, tobacco, and mustard.
 - (b) Cereal crop e.g. wheat, paddy, millet, maize, sorghum, pulses.
 - (c) Pests of vegetables, fruits and oil seed crops.
 - (d) Cash fibre crops e.g. cotton, sun hemp etc.
 - (e) Pests of medical and veterinary importance with reference to role of WHO and UNICEF. Insect borne diseases (A preliminary idea).
 - (f) Storage pests (Stored grains and milled products) with an elementary idea of different types of storage.
9. Inset Control: Basic idea.
10. Various methods of insect control
 - (a) Prophylactic and cultural method, Quarantine regulation.
 - (b) Physical control.
 - (c) Chemical control.
 - (d) Biological control


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- (e) Insect pest management, its strategies and tools in IPM. Its relevance in insect pest control.
11. Chemistry and mode of action of insecticides
- (a) Inorganic insecticides.
 - (b) Organochlorine insecticides
 - (c) Organophosphorus compounds and carbonates.
 - (d) Insecticides of plant origin.
 - (e) Synthetic pyrethroids.
 - (f) Insect growth regulatory compounds.
 - (g) Microbial insecticides.
 - (h) Chemosterilant, repellents, antifeedants.
 - (i) Fumigants and fumigation.
12. Concept I, II and III generation of insecticides
- 12.1 A brief idea of appliances used for application of insecticides, hazards involved and safe handling of insecticides
 - 12.2 Development of resistance in insects to insecticides.
 - 12.3 Insecticide synergists and antagonists.
 - 12.4 Insecticide formulations and application technology.
 - 12.5 Dynamics of environmental pollution.
 - 12.6 Pesticides: Impact on wildlife and human health (bioaccumulation, biomagnification, biodegradation)
 - 12.7 Microbial and environmental degradation of pesticides.
13. Forensic entomology with special reference to man and wildlife.
14. Beneficial insects: Silk worm, honeybee and lac insect and industries related to them.
15. Role of genetics in vector control.
16. Social insects, social organization, caste differentiation.

List of Practicals:-

- 1. Field trips for collection and preservation of insects of various orders.
- 2. Museum study for identification of insects of different orders.
- 3. Dissection
 - (a) Cockroach: Digestive, nervous, circulatory, reproductive systems and neuroendocrine complex.
 - (b) Grasshopper
 - (c) Honeybee: Digestive and nervous system.
 - (d) White grubs: Nervous system.

- (e) Housefly.
4. Permanent preparations
 - (a) Different types of mouthparts, antennae, legs and wings.
 - (b) Sting apparatus of honeybee.
 - (c) Pollen basket of honeybee.
 - (d) Tympanum and spiracle of grasshopper.
 - (e) Whole mounts (wm.) of various small insects.
5. Familiarity with techniques of appliances used for the application of insecticides
 - (a) Sprayers including hand sprayers.
 - (b) Dusters.
6. Knowledge of rearing insects and maintaining insectary
 - (a) *Tribolium* Sp.,
 - (b) *Rhizopertha* Sp.,
 - (c) *Heliothis* Sp.,
 - (d) *Corcyra* Sp.,
 - (e) *Callosobruchus* Sp.,
 - (f) *Lasioderme serricorne*, mosquito species.
7. Testing of insecticides: bioassay methods.
8. Study of prepared slides
 - (a) Whole mounts of insects.
 - (b) Histology.
 - (c) Leg types.
 - (d) Antennae types.
 - (e) Types of mouthparts.
 - (f) Wing types.
9. Microtomy (Internal organs of insects).
10. Study of seasonal abundance of crop-pest in nearby area.
11. Live demonstration of biological control using *Coccinella* or *Chrysopa*
12. Role of hormones in metamorphosis (ligature experiment with Housefly larvae).
13. To study antennal grooming in cockroach.
14. To study the blood cells in insects.
15. To study meiosis and polytene chromosomes in insects.
16. To study the insects infestation in the grains.
17. To study the food preference of *Tribolium* or any other insect.

**SCHEME OF ENTOMOLOGY
PRACTICAL EXAMINATION**

Duration : 6 Hours

Max. Marks – 100

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

Total = 100

Recommended Books:

1. Borror, D.J. and DeLong, D.M.: An Introduction to the Study of Insects. Constable and co. London/Holt, Rinehart and Winston. New York. 1954.
2. Chapman R.F. The Insects: Structure and Functions, Cambridge Low Price, Edition, 1998.
3. Dhaliwal, G.S. and Arora, Ramesh. Principles of insect. Pest management National Agricultural Technology Information, Ludhiana, 1976.
4. Essig, E.Q. College Entomology: MacMillan Co. New York, 1942.
5. Fox, R.M. and Fox, J.W.: Introduction to comparative Entomology, Reivehold Puse, Corp. New York, 1964 (Indian Reprint: Affiliated East West Press Pvt. Ltd., New Delhi.
6. Frost, S.W. Insect Life and Insect Natural History dover Puse. Inc. New York, 1969.
7. Imms. A.D. : Recent Advances in entomology. Churchill. London. 1931.
8. Imms. A.D.: A General Text book Entomology. Methuen and Co.: London. 1957 (Low priced reprint; English Language Book London, 1972.)
9. Kilgore, W.W.: and Dout, R.L.: Pest Control, biological, physics and selected chemical methods. Academic press, New York, London, 1967.
10. Kumar Ashok and Nigam, P.M.: Economic and applied Entomology Emkay Publication, Post Box NO. 9410, B-19, East Krishna Nagar, Delhi-110051.
11. Lefroy, H.F.: Indian Insect life. Today and tomorrow printers and Publishers, New Delhi 1971.
12. Lefroy, H.F.: Indian Insect Pest. Today and Tomorrow Printers and Publishers, New Delhi 1971.
13. Little, V.A.: General and Applied entomology. Harper and Row. New York, 1960. (Indian Reprint: Oxford and IBH Publishing, New Delhi 1973.
14. Mani M.S.: Modern Classification of Insects. Satish Book Enterprise, Agra.1974.
15. Mani. M.S.: General Entomology. Oxford and IBH. Publ. co., New Delhi. 1968.

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16. Metcalf. C.L. and Flint. W.P.: Destructive and Useful Insects. McGraw Hill Book Co. New York. 1962 (Indian reprint: Tata McGraw-Hill Pubi. Co.: New Delhi).
17. Nayar, K.K., Anantkrishnan, T.N. and David, B.V., General applied entomology. Tata McGraw-Hill Publishing Limited, Delhi, 1976.
18. Pruthi, H.S.: Text book of Agricultural entomology. Indian council of Agricultural Research, New Delhi. 1969.
19. Roeder. K.D.: Insect Physiology. John Wiley and Sons Inc. New York. 1953.
20. Ross, H.H.: A Text Book of entomology. John Wiley and Sons, New York. 1965.
21. Snodgrass, R.E. : Principles of Insect Morphology. McGraw-Hill Co. new York 1953 (Indian Reprint Tata McGraw-Hill Pul. Co. New Delhi. 1971)
22. The year book of Agriculture, U.S. Department of Agriculture, Washington, D.C.
23. Wiggsworth. V.B.: The Principles of Insect Physiology. Methuen and co. London. 1972 (Low Priced text reprint: English Language Book Society London. 1972)

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 arid reef

2. Biological Communities

2.1 Critical factors & Tolerance limits


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- 2.2 Natural selection, Adaptation and evolution
- 2.3 Ecological niche
- 3. Species interactions
 - 3.1 Predation
 - 3.2 Competition
 - 3.3 Symbiosis
- 4. Community Dynamics
 - 4.1 Productivity
 - 4.2 Abundance and diversity
 - 4.3 Complexity & connectedness
 - 4.4 Resilience & diversity
 - 4.5 Community structure
 - 4.6 Edges and boundaries
- 5. Communities in transition
 - 5.1 Ecological succession
 - 5.2 Introduced species and community change
- 6. Restoration Ecology
 - 6.1 Natural
 - 6.2 Restoring keystone species and ecological process
 - 6.3 Mitigation and replacement
 - 6.4 Creating 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
 - 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

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- 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
 - 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
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


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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.
3. Bioassay of polluted water using microbes or any other higher animal (fish).
4. Pesticide residue analysis using GC and TLC techniques
5. Water pollution detection (microbial).
6. Trips to natural habitat and 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

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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 physiochemical 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

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. Singapore.
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.

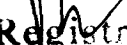
7. FISH BIOLOGY

PAPER-V: FISH BIOLOGY

Duration : 3 Hours

Max. Marks – 100

1. Classification of fishes with special reference to evolutionary trends and adaptations. 3
2. Integument and exoskeleton. 3
3. Fins: Types of fins structure, modifications and functions of fins 3
4. Locomotion: Locomotion muscle, the red (slow) and white (fast) muscle fiber types modes of swimming and hydro mechanics of propulsion; role of fins in swimming; significance of swimbladder in swimming; non-swimming locomotion. 5
5. Food, feeding habits and feeding adaptations/behaviour, structure of the alimentary canal and physiology of digestion and absorption. 3
6. Planktons: Classification, common organisms and their importance; algal bloom, nutrient cycle, trophic levels and energy flow. 5
7. Blood vascular system: Structure of the heart; principal blood and circulation of blood (elasmobranch, teleost and Dipnoi) 5
8. Gills and aquatic respiration organization of gills in fishes; structure of a typical teleostean gill, physiology of gill respiration; gill ventilation, gill surface area, blood flow through gills, water blood barrier, gas exchange at the gill surface and gas exchange between blood and tissues. 5
9. Air breathing fishes; causative factors and structural adaptations. 3
10. Structure and functions of the kidney; nitrogenous and products and pattern of their excretion. 3
11. Water and electrolyte regulation in marine, fresh water and euryhaline fishes. 2


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| 12. | Structure and functions of the swimbladder. | 2 |
| 13. | Study of feeding habits of fish through qualitative and quantitative analysis of gut contents of herbivorous carnivorous and omnivorous species. | 4 |
| 14. | Nervous system: Structure and functions fo the central, peripheral and autonomic nervous systems; anatomy and function of the Mauthner neurons. | 4 |
| 15. | Structure and functions of the sense organs: | 5 |
| | 15.1 Eye; visual pigments and vision | |
| | 15.2 Chemoreceptors: Olfactory and gustatory; biological significance of chemoreception. | |
| | 15.3 Labyrinth. | |
| | 15.4 Mechanoreceptors (lateral line organs) | |
| 16. | Structure and physiology of the endocrine organs and tissues: | 12 |
| | 16.1 Pituitary | |
| | 16.2 Thyroid | |
| | 16.3 Gonads. | |
| | 16.4 Adrcnal. | |
| | 16.5 Endocrine pancreas. | |
| | 16.6 Ultimobranchial. | |
| | 16.7 Caudal neurosecretory cells and urophysis. | |
| | 16.8 Pineal. | |
| 17. | Reproduction: Organs of reproduction; modes of reproduction; oviparity, viviparity hormonal and environmental regulation of reproduction. | 5 |
| 18. | Reproductive behaviour: Secondary sexual characters, nest building and parental care. | 2 |
| 19. | Development: Types of eggs; fertilization; hatching and metamorphosis | 2 |
| 20. | Adaptations: Coloration, sound production, electric, organs, luminescent organs (location, structure, physiology and biological significance). | 2 |
| 21. | Adaptations in deep sea, hill-stream and cave-dwelling fishes; freezing avoidance in arctic and antartic fishes. | 3 |
| 22. | Migration; its types and causes. | 2 |
| 23. | Fish pathology: Symptoms, etiology, prophylaxis and treatment of common diseases and pathological condition in cultivable fish. | 2 |
| 24. | Setting-up and maintenance of an aquarium. | 2 |
| 25. | Fish products and by products: Liver oil, body oil, meal, fish manure, guano, glue, isinglass, roe (caviar), fins and leather. | 2 |

Note:

1. It should be ensured that animals used in the practical exercise are not covered under the wild life act 1972 and amendments made subsequently.

7. FISH BIOLOGY

PAPER-VI: AQUACULTURE AND FISHERIES

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Definitions of (a) inland, (b) marine (c) capture (d) culture fisheries. 3
2. Riverine fisheries: Ecology and fisheries of the major river systems; effects of dams and barrages on riverien fisheries. 6
3. Reservoir fisheries: Location, ecology and fisheries of some important reservoirs; development, exploitation and management of reservoir freshwater fisheries. 6
4. Coldwater fisheries: Ecology of high altitude streams lakes and reservoirs; present status and scope for development of important coldwater fisheries. 6
5. Estuarine fisheries: Ecology and fishery resources of major estuaries; potential and management of estuarine fisheries. 6
6. Marine fisheries
 - 6.1 Ecology and general survey of marine capture fisheries with special reference to sardine, mackerel, Bombay duck and Pomfret. 6
 - 6.2 Offshore and deep sea fishery Potential in EEZ (Exclusive Economic Zone) 1
7. Estimation of fecundity and population dynamics and fishery catches. 3
8. Growth and age; environmental factors and methods. 3
9. Crustaceans and Molluscan fisheries (Marine water, Brackish water and Fresh water). 3
10. Methods of Fishing: Crafts (non-mechanised and mechanised) and gears used in India for fishing: in inland,marine water; recent advances in fishing methods, electrical fishing; light fishing, fish finders (Eco-sounder and sonar) and their use. 3
11. Transport and preservation of fish: Methods of transport, post mortem changes and rigor mortis in fish; spoilage (bacterial and chemical); fish preservation-handling and cleaning of fresh fish, ceiling, freezing, quick freezing, use of chemicals and antibiotics irradiation, salting, drying freeze-drying, smoking, canning and pickling. 5
12. Fishery management: Fish yield, effect of fishing on yield and optimum catch, concept of a rational fishery. 3
13. Ecology and Productivity of freshwater lake and perennial fish pond indices of productivity; physical and chemical characteristics of water, nature and fertility of the soil. 3
14. Environment and fish: Environmental factors (abiotic and biotic), interrelation to the life of fishes; pollution of ecosystems sources of pollution and nature of pollutants, effects of pollution on fisheries, legislative and other remedial measures to contain aquatic pollution. 3
15. Freshwater fish culture in India; Fish seed resources (riverine, bundh breeding, hypophysation) hatching of eggs, hatchlings, 'hapas' and different types of hatcheries, management of hatcheries; methods of transporting fish seed, fingerlings and breeders; causes of mortality during transportation and measures for reducing it. 7

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16. Planning and management of freshwater ponds for fish culture (freshwater fish-farming); survey of site, layout, soil and water requirements; preparation of nursery, rearing and stocking ponds, control of predators and weed fishes; liming, and manuring; control of aquatic insects and weeds; procurement and segregation of fish seed; stocking rates; stocking ratios of different species for composite culture; artificial feed and supplement feeding, harvesting. 7
17. Culture of Indian major carps (Rohu, Catla and Mrigal), exotic carps, Common carp, grass carp, silver carp and tilapia; composite culture principle, techniques and significance: Wet and dry bundh technique, induced breeding, hypophysation, selective breeding and hybridization. 6
18. Cold-water culture of trout: Mahseer, culture method and management.
19. Larvivorous fishes and their importance. 2
20. Nutrition and physiological energetic: Nutritional requirement of fish with reference to proteins, lipids, carbohydrates, vitamins and minerals; essential amino acids and essential fatty acids; energy requirements; food conservation, efficient energy budgets. 2
21. Fish as food: Biochemical composition of raw fish, factors affecting biochemical composition of fish; nutritive value of raw and preserved fish; poisoning, toxicity and allergies from fish as food; quality control of fish as food. 2
22. Fisheries education, training and extension in India : Brief information about the objectives and functions of Central Institute of Fisheries Education (Bombay), Central Inland Capture Fisheries Research Institute (Barrackpore), Central Institute of Freshwater Aquaculture (Chennai), National Bureau of Fisheries Genetics Resources (Lucknow), Central Marine Fisheries Research Institute (Cochin), Central Institute of Fisheries Nautical and Engineering Training (Cochin), Central Institute of Fisheries Technology (Cochin) and National Institute of Oceanography (Goa). 2

List of Practicals Exercises

1. Study of distinguishing features, identification and classification of specimens of important species of fish available in the museum; Collection of local fish fauna and its identification upto the species level using taxonomic keys.
2. **Anatomy and Histology:**
 - (a) Study of anatomy of teleost represented by the catfish *Wallago attu*:
External anatomy and gills, viscera, alimentary canal and urinogenital organs; musculature for gill ventilation, and feeding; eye muscles and their innervation, endoskelton (through dried and alizarin preparation), branchial blood vessels, brain and cranial nerves, swim bladder, Weberian ossicles, membranous labyrinth connections.
 - (b) Preparation and study of stained permanent mounts of Ampullae of Lorenzini (from *Dasyatis*), otolith, scales (Placoid, cycloid and ctenoid), gill filament and olfactory lamella.
 - (c) Dissection of air-breathing organs and their blood supply in *Anabas testudineus*, *Clarias batrachus*, *Heteropneustes fossilis* and *Channa* sp.
 - (d) Study of fish anatomy and histology through available slides.
3. Preparation of microscopic slides of stained, sections of following organs/tissues structures from an adult teleost for their histological study of liver, intestine, kidney,

16. Planning and management of freshwater ponds for fish culture (freshwater fish-farming); survey of site, layout, soil and water requirements; preparation of nursery, rearing and stocking ponds, control of predators and weed fishes; liming, and manuring; control of aquatic insects and weeds procurement and segregation of fish seed; stocking rates; stocking ratios of different species for composite culture; artificial feed and supplement feeding, harvesting. 7
17. Culture of Indian major carps (Rohu, Catla and Mrigal), exotic carps, Common carp, grass carp, silver carp and tilapia; composite culture principle, techniques and significance: Wet and dry bundh technique, induced breeding, hypophysation, selective breeding and hybridization. 6
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21. Fish as food: Biochemical composition of raw fish, factors affecting biochemical composition of fish; nutritive value of raw and preserved fish; poisoning, toxicity and allergies from fish as food; quality control of fish as food. 2
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List of Practicals Exercises

1. Study of distinguishing features, identification and classification of specimens of important species of fish available in the museum; Collection of local fish fauna and its identification upto the species level using taxonomic keys.
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 - (a) Study of anatomy of teleost represented by the catfish *Wallago attu*:
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 - (b) Preparation and study of stained permanent mounts of Ampullae of Lorenzini (from *Dasyatis*), otolith, scales (Placoid, cycloid and ctenoid), gill filament and olfactory lamella.
 - (c) Dissection of air-breathing organs and their blood supply in *Anabas testudineus*, *Clarias batrachus*, *Heteropneustes fossilis* and *Channa* sp.
 - (d) Study of fish anatomy and histology through available slides.
3. Preparation of microscopic slides of stained, sections of following organs/tissues structures from an adult teleost for their histological study of liver, intestine, kidney,

testis, ovary, gill, pituitary, thyroid tissue, head kidney (for interrenal and chromaffin cells).

4. ***Physiology and biochemistry.***

- 4.1 Study of the effect of epinephrine, NaCl and KCl on fish chromatophores.
- 4.2 Study of changes in chromatophores of fish kept against white (light) and black (dark) backgrounds for protracted periods.
- 4.3 Determination of the rate of oxygen consumption (Winkler method) in a water breathing fish at different temperatures.
- 4.4 Determination of the rate of ammonia and urea excretion in fish.
- 4.5 Estimation of protein, fat, ash and water contents in fish muscle.
- 4.6 Study of free amino-acid pool in fish muscle through paper chromatography.

5. ***Basic Laboratory Techniques:***

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

Ecology: Physico-chemical analysis of water.

Age and growth.

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

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

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

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

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

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

Fieldwork and study tour

- 1.1 A visit to a fish farm/fish seed production centre.
- 1.2 3 to 4 day tour to study various fisheries activities at selected centres/sites.

Note:

1. It should be ensured that animals used in the practical exercise are not covered under the wild life act 1972 and amendments made subsequently.
2. Slides from exercise to be submitted at the time of examination.

PRACTICAL EXAMINATION SCHEME

Duration : 6 Hours

Max. Marks – 100

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

Note:

1. Submission of slides from the above 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.

Recommended Books

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

8. RADIATION BIOLOGY


PAPER-V: BASIC OF RADIATION

Duration: 3 Hours

Max. Marks – 100

Periods : 90

1. Atomic Structure
 - 1.1 Theories of atomic structure.
 - 1.2 Isotopes, isomers and isobars.


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- 1.3 Mass Number and Atomic mass.
- 1.4 Sub-atomic particles.
- 1.5 Excitation and ionization.
- 1.6 Nuclear forces and nuclear structure.
2. Types of Radiation.
 - 2.1 Nuclear Radiation.
 - 2.2 X-rays-characteristics, production and uses.
3. Radioactivity
 - 3.1 Natural radioactivity.
 - 3.2 Artificial radioactivity.
 - 3.3 Half-life.
 - 3.4 Natural decay series.
 - 3.5 Background radiation.
4. LET and RBE
5. Radiation Dosimetry
 - 5.1 Units of radiation and radioactivity.
 - 5.2 X-rays dosimetry
 - 5.3 Radiation weighting factors and equivalent dose.
 - 5.4 Tissue weighting factor and effective dose.
 - 5.5 Cumulative doses.
 - 5.6 External and internal dosimetry.
 - 5.7 Microdosimetry.
 - 5.8 Maximum Permissible Dose (MPD)
6. Detection and measurement of radiation
 - 6.1 Ionization chamber.
 - 6.2 Scintillation detectors.
 - 6.3 G.M. counter.
 - 6.4 Proportional counter.
 - 6.5 Gamma ray spectrophotometer.
 - 6.6 Autoradiography, RIA.
7. Radiation chemistry
 - 7.1 Radiolysis of water.
 - 7.2 Hydrogen peroxide formation.
 - 7.3 Reactions in aqueous organic solutions.
 - 7.4 Direct and indirect effects.
 - 7.5 Oxygen effect.

8. Sources of Radiation Hazards
 - 8.1 Natural sources.
 - 8.2 Artificial sources.
 - 8.3 Sealed and unsealed sources.
 - 8.4 External radiation hazards.
 - 8.5 Internal Radiation hazards.
9. Radiation Monitors
 - 9.1 Personnel monitoring equipments.
 - 9.2 Film badge.
 - 9.3 Pocket dosimeter.
 - 9.4 Thermo Luminescence Dosimetry (TLD)
 - 9.5 Area monitoring.
10. Radioactive Contamination and Decontaminations
 - 10.1 Source of contamination.
 - 10.2 Control of contamination.
 - 10.3 Contamination monitoring.
 - 10.4 Decontamination.
11. Radioactive waste management
 - 11.1 Characteristics of radioactive waste.
 - 11.2 Management of nuclear waste.
 - 11.3 Discharge of wastes.


PAPER-VI: RADIATION EFFECTS

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1. Interaction of radiation with matter.
 - 1.1 Direct effects of ionizing radiation.
 - 1.2 Indirect effect of ionizing radiation (photoelectric effect, Compton effect, pair production).
 - 1.3 Bremsstrahlung effects.
 - 1.4 Interaction of neutrons.
 - 1.5 Nuclear fission and fusion (production of isotopes, nuclear reactors and accelerators).
2. Cellular radiobiology
 - 2.1 Apoptosis.
 - 2.2 Reproductive cell death.


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- 2.3 Survival curves.
- 2.4 Radiosensitivity of cell cycle phases.
- 2.5 Factors influencing radio sensitivity (oxygen effect & chemical modifiers).
- 2.6 Classification of mammalian cell sensitivity.
- 2.7 Effects of radiation on macromolecules including repair (Nucleic acids, Proteins).
3. Acute radiation effects
 - 3.1 Concept of LD₅₀
 - 3.2 Central nervous system syndrome.
 - 3.3 Gastro-intestinal syndrome.
 - 3.4 Bone marrow syndrome.
 - 3.5 Skin reactions.
4. Delayed effects of radiation
 - 4.1 Stochastic and deterministic effects.
 - 4.2 Radiologic aging.
 - 4.3 Life shortening.
 - 4.4 Radiation carcinogenesis.
5. Radiation effects on embryo and foetus
6. Radiation immunology
 - 6.1 Immunity response.
 - 6.2 Radiation as immunosuppressive agent.
 - 6.3 Long term changes in the immunological reactivity of the irradiated organisms.
7. Cytogenetic effects of radiations.
 - 7.1 Chromosomal aberrations.
 - 7.2 Micronuclei induction.
 - 7.3 Radiation mutations.
8. Radiation Hormesis.
 - 8.1 Evolution of current radiation paradigms.
 - 8.2 Epidemiological evidence.
 - 8.3 Experimental studies and adaptive response.
9. Radiation hazard evaluation and control
 - 9.1 Control of external hazards.
 - 9.2 Control of internal hazards.
 - 9.3 Exposure rate, constant.
10. Radiation Accidents (special reference to Rajasthan-Pokharan I & II)
11. Radiation safety and regulatory aspects
 - 11.1 Radiographic installations.

- 11.2 Enclosed installations.
- 11.3 Field installations.
- 11.4 Personnel management.
- 11.5 Source storage facilities.
- 11.6 Safe work practice.
- 11.7 Re-commendations of National/International statutory bodies.

LIST OF PRACTICAL EXERCISES

Radiation Biology

1. Knowledge and use of: Geiger-Muller counters. Decade Scalar, Scintillation counters (Crystal and Liquid), Survey meter, Single-channel gamma spectrometer, Actigraph system, Cobalt camera, T're foil.
2. Finding out the operating voltage of the G. M. tube.
3. Calculation of Inverse Square Law.
4. Determination of the resolving time of the G.M. tube.
5. Absorption of beta and gamma rays.
6. Determination of self-absorption factor.
7. Determination of backscattering factors.
8. Finding out the physical half-life of a given isotope:
 - (a) Single isotope method.
 - (b) From a mixture of two isotopes.
9. Autoradiography
 - (a) Liquid-emulsion method.
 - (b) Stripping film method.
10. Histopathological, histochemical and biochemical studies of various tissues after external and Internal irradiation.
11. Personnel monitoring. Use of G.M. survey meter, Film badge, and Room Contamination monitor.
12. Study of permanently prepared histopathological slides.
13. Decontamination of contaminated material.
14. Visits to the Radiology Department, S.M.S. Medical College, Jaipur, Rajasthan; Atomic Power Project, Kota and Bhabha Atomic Research Centre, Mumbai.
15. Class Record & Seminar.
16. Viva-voce.

Note:

1. Submission of slides from the above 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.

SCHEME OF PRACTICAL EXAMINATION

Duration : 6 Hours

Max. Marks – 100

1. Major exercise (1)	24 marks
2. Minor exercise (1)	16 marks
3. Preparation and study of a histopathological slides/histochemical/ biochemical estimation of various macromolecules in different tissues (Proteins, Glycogen, Cholesterol, Nucleic acids etc.)	16 marks
4. Spotting (8)	24 marks
5. Record & Submission of slides	5+5 marks
6. Viva-voce	10 marks

Recommended Books

1. Advanced Medical Radiation Dosimetry. Rajan O. Prentice-Hall of India Pvt. Ltd. New Delhi, 1992.
2. Applied Radiobiology of Radiation Protection. Granien, R., Prentice Hall, 1990.
3. Basic Radiation Biology. Pizzarello D.J., Witcofsli Lea R. L. and Febiger: Philadelphia, 1970 or Later.
4. Biological Aspects of Human Irradiation Eds. Pant, G. S. and Basu, AK. Himalaya Publishing House, Delhi, 1992.
5. Biological Assessment of occupational Exposure to Actinides. G. B. Gendes, H. Metives and J. Stathes: Nuclear Tech. Pub. Kent, 1989.
6. Biological Effects of Radiation. Coggle. J.E. : Taylor and francis Ltd., London, 1988 or Later Edition.
7. Biological Effects of Radiations. Grosel, D. S. and Hop Zwood, L.E. Academic Press, New York, 2nd Edition, 1979 or Later Edition.
8. Biological Radiation effects. Kiefer, J. Springer-Venlag, Berlin, 1989.
9. Cellular Radiobiology. Lawrence c.w. Arnold, London, 1971 or Later Edition.
10. Developmental Effects of Prenatal Irradiation. Kriegel, H.. VCH,. 1982.
11. Elements of Radiobiology, Seivan J. Thomas, C. C. 1983.
12. Environment and Human Risks of Tritium, Gesben, G., C. M. Menaene and H. Smilts: Nuclear Tech. Pub. Kent, 1986.
13. Essential of Radiation Biology and Protection, Steve Forshie: Publisher: Delmar Cengage Learning.
14. Frontiers of Radiation Biology. Riklin, E. ed. VCH, 1990.
15. Health Effects of Low Level Radiation, Hendec. w. R. : Prentice Hall. 1984.
16. Human Radiation Biology. Prasad, K. N., CRC Press, inc. Cleveland, Ohio, USA, 1984.
17. Introductory Biostatistics for the Health Sciences. Duncan R. C., Knapp., R. G., and Miller III, M.C., :John Wiley and Sons· Inc., New York, 1977 or Later Edition.
18. Ionizing Radiation and Life. Mosby, Avena, V: S1. Lonis. 1971 or Later Edition.

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19. Low Dose Radiation Biological Bases of Risk Assessment. Baverstock, K. of Staltar, J. Taylor of Francis, 1989.
20. Low level Radiation and Living State. Huilgol. N. G. et al.: Naraza Publishing House, Community Center Panchsheel Park, New Delhi, 1993.
21. Low level Radiation Effects. Broil. AB. A fact Book: Society of Nuclear Medicine, USA, 1982.
22. Medical Radiation Biology. Dalrymple, G. V, Ganldev, M.E., Kollmorgen, G. M. and Vogel, H. J. Saunders. Philadelphia, 1973 or Later Edition.
23. Radiation and Life. Hall. E. I. : Pergamon Press, Oxford, U. K. 2nd Edition, 1987.
24. Radiation Biophysics. Prentice –Hall Engel-Wood Cliffs. Andrews, H. L.: New Jersey. 1974 or Later Edition.
25. Radiation Carcinogenesis. Upton, A. C. Ehseviees, 1986.
26. Radiation Exposure and Occupational Risks. Scheres, E., c. Streffer, K. R. Trott.: Eds. Berlin, 1990.
27. Radiobiological Consequences of Nuclear Accidents –Contamination Radioecology, Bulokav FB., V Naiitel and J. B. Reitan: Radiobiology and Health.
28. Radiobiology for the Radiologist. 3rd Edition, Hall. E. L. : Harper and Row, 1990 or Later Edition.
29. Radiobiology. Fobrikant. J. I. : Year book med., Chicago, 1972 or Later Edition.
30. Radioisotope Methodology. Chase, GD. and Robinowitz, J. L. Burgess Publishing Co. Minneapolis, Minn, USA. 3rd Edition, 1967 or Later.

9. REPRODUCTIVE BIOLOGY


PAPER-V: ENDOCRINE GLANDS AND REGULATORY PROCESSES

Duration : 3 Hours

Max. Marks ~ 100

Periods : 90

- | | | |
|----|---|----|
| 1. | Endocrine glands: An overview | 1 |
| 2. | Biochemical nature of hormones. | 2 |
| 3. | Mechanism of hormone actions. | 5 |
| 4. | Structure and nomenclature of steroid hormones, steroidogenesis. | 5 |
| 5. | The female reproductive system: Comparative anatomy and physiology of the mammalian and sub mammalian. ovary and ductal system. Follicular growth, kinetics and atresia, ovarian hormone two cell theory of estrogen biosynthesis. Autocrine, Paracrine and endocrine regulation of ovarian functions. | 12 |
| 6. | The male reproductive system: Comparative anatomy and physiology of the mammalian and sub mammalian testis, epididymis and the sex accessory glands; Functional organization of testis, spermatogenic cycle. Testicular androgens, autocrine, paracrine and endocrine regulation of testicular functions. Semen and its biochemical nature. | 12 |
| 7. | Regulation of reproduction | 10 |


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

9. REPRODUCTIVE BIOLOGY


PAPER-VI: REPRODUCTIVE TECHNOLOGICS

Duration : 3 Hours

Max. Marks – 100

Periods : 90

1.	Fundamental aspects of control of fertility in males:	12
1.1	Mechanical.	
1.2	Surgical.	
1.3	Chemical.	
1.4	Immunological methods	
2.	Fundamental aspects of control of fertility in females:	14
2.1	Natural.	
2.2	Mechanical.	
2.3	Surgical.	


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2.4	Chemical.	
2.5	Immunological.	
2.6	Emergency contraception.	
3.	Control of fertility in Insects.	3
4.	Induced spawning in Fishes.	2
5.	Techniques for improvement of breeding farm animals.	4
6.	Anatomy and physiology of the endocrine and neuroendocrine structures of annelids, arthropods and mollusca with special reference to their role in reproduction.	10
7.	Reproductive dysfunctions in males and females.	6
8.	Diagnosis of male infertility.	6
8.1	Semen analysis: Physical examinations, microscopic examinations, biochemical analysis, immunological tests.	
8.2	Sperm function tests: Sperm mitochondrial Hypo-osmotic swelling test, acrosome, reactin, Zona binding assays, Acrosome intactness test, and hamster-oocyte penetration test.	
8.3	Endocrinological diagnosis.	
9.	Diagnosis of female infertility.	6
9.1	Monitoring of ovarian and reproductive cycles.	
9.2	Endometrial biopsy.	
9.3	Ductal blockage.	
9.4	Endocrine diagnosis.	
10.	Assisted Reproductive Technology (ART).	8
10.1	Super ovulation, oocyte collection.	
10.2	Collection and preparation of sperm for assisted fertilization.	
10.3	Insemination.	
10.4	<i>In vitro</i> fertilization and related techniques (IVF, GIFT, ZIFT, TESE, ICSI).	
10.5	Assisted Zona hatching (AZH), Autologous endometrial co-culture , cytoplasmic transfer surgical sperm retrieval (SSR)	
11.	Cryopreservation of semen, oocytes and embryos.	2
12.	Cloning, transgenic animals.	2
13.	Teratological effects of xenobiotics.	2
14.	Pre-natal diagnosis.	1
15.	Impact of aging, hormone replacement therapy.	3
16.	Hormonal bioassay (FSH, LH, Testosterone, TSH & ACTH)	7
16.1	ELISA.	
16.2	Radio Immuno assay (RIA).	
16.3	Radioreceptor binding assay.	

LIST OF PRACTICAL EXERCISES

Practicals:

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

Note:

1. **Submission of slides from the above 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.**

SCHEME OF PRACTICAL EXAMINATION

Duration : 6 Hrs.

Max. Marks : 100

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

Total 100

Recommended Books

1. A Text Book of comparative Endocrinology. Gorbman, A and Bern, H. A. John Wiley and Sons Inc., New York, 1962. (Indian reprint, Wiley Eastern Pvt. Ltd., New Delhi, 1974).
2. An Introduction to General and Comparative Endocrinology by Barrington: E. J. W. Clarendon Press, Oxford, 1963

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3. Andrology Male Reproductive Health and Dysfunction. Nieschlag F. and Behre H.M Springer-Verlag, Berlin-2001
4. Biology of Gestation. Assali, N. S. (ed.) Vol. I and II Academic Press, New York.
5. Biology of Human Reproduction. Pinon, Jr. R. University Science Books, California, 2002.
6. Biology of ovarian follicles in Mammals. Guraya, S. S., Springer Verlag, Berlin.
7. Comparative Reproductive Biology Reviewed. Ali Honaramooz, Blackwell Publishing House, Ames, Iowa, USA, 2007.
8. Comparative Vertebrate Endocrinology, Benttey P.
9. Delayed Implantation Enders, N.C. University of Chicago Press, Chicago. 1963.
10. Encyclopedia of Reproduction. Vol. I to IV. Knobil E. and Neill J.D. Academic Press, New York, 1998.
11. Essential Reproduction. M. H. Johnson, Barry J. Everitt Blackwell publishing ,USA 2007.
12. General Endocrinology. Turner, C.D., W B. Saunders and Co., Philadelphia (Tappan International. Edition, Tappan Co. (Singapore) Pvt. Ltd., New Delhi, 1974).
13. Hormones. Norman AW. and Litwack G. Academic Press, New-York, 1997.
14. Human Physiology (Vol. II), C.C. Chatterjee.
15. Knobil and Neill's physiology of reproduction, Vol. I and II, Ernst Knobil, Jimmy D. Neill Academic Press, 2006.
16. Marshall's Physiology of Reproduction Parkes. A. S. Vols. 1; Part 1 (1956) and 2 (1960) 3 (1952) and 4 (1966) Longmans, Green and Co., London. .
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