

  
**UNIVERSITY OF MYSORE**  
Estd. 1916

Vishwavidyanilaya Karyasoudha  
Crawford Hall, Mysuru- 570 005  
Dated: 24.07.2018

No.AC.2(S)/31/18-19

**NOTIFICATION**

**Sub:** Revision in credit pattern of Zoology (PG) from the academic year 2018-19.

**Ref:** 1. Decision of Board of Studies in Zoology (PG) meeting held on 08.12.2017.  
2. Decision of the Faculty of Science & Technology Meeting held on 21.04.2018.  
3. Decision of the Academic council meeting held on 19.06.2018.

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The Board of Studies in Zoology (PG) which met on 08.12.2017 recommended to revise credit pattern and contents of M.Sc. Zoology from the academic year 2018-19.

The Faculty of Science and Technology and the Academic council meetings held on 21.04.2018 and 19.06.2018 respectively have approved the above said proposal and the same is hereby notified.

The revised credit pattern of M.Sc. Zoology course is annexed. The contents may be downloaded from the University Website i.e., [www.uni-mysore.ac.in](http://www.uni-mysore.ac.in).

Draft approved by the Registrar

**Sd/-**  
**Deputy Registrar (Academic)**

**To:**

1. The Registrar (Evaluation), University of Mysore, Mysore.
2. The Dean, Faculty of Science & Technology, DOS in Physics, Manasagangotri, Mysore.
3. The Chairperson, BOS in Zoology, DOS in Zoology, Manasagangotri, Mysore.
4. The Chairperson, DOS in Zoology, Manasagangotri, Mysore.
5. The Director, College Development Council, Moulya Bhavan, Manasagangotri, Mysore.
6. The Deputy/Assistant Registrar/Superintendent, AB and EB, UOM, Mysore.
7. The P.A. to the Vice-Chancellor/Registrar/Registrar (Evaluation), UOM, Mysore.
8. Office file.

Overview of courses offered for M.Sc. Zoology program w.e.f. 2018-19 academic sessions

I SEMESTER

Sl. No	Title	Credits			Total credits
		L	T	P	
1	Non-Chordata – Hard Core - 1	3	0	1	4
2	Transmission Genetics -Hard Core - 2	3	0	0	3
3	Cell Biology- Hard Core - 3	3	0	0	3
4	Animal Physiology - Hard Core - 4	2	0	2	4
5	Practical Cytogenetics - Hard Core - 5	0	0	2	2
6	Biological Chemistry - Soft Core – 1*	2	0	2	4
7	Vectors & Communicable diseases – Soft Core – 2*	3	1	0	4
<b>*Any one soft core to be opted</b>					<b>Minimum credits to be offered: 20</b>

II SEMESTER

1	Chordata – Hard Core - 6	3	0	1	4
2	Reproductive Biology- Hard Core – 7	3	0	0	3
3	Practical Reproductive Biology & Histology - Hard Core - 8	0	0	2	2
4	Molecular Biology - Hard Core -9	3	0	1	4
6	Histology and Histopathology - Soft Core – 3*	3	0	0	3
7	Advanced Genetics - Soft Core – 4*	4	0	0	4
8	Principles of Animal Science – Open Elective-1	3	1	0	4
9	Drosophila Genetics - Open Elective-2	3	1	0	4
<b>*Any one soft core to be opted</b>					<b>Minimum credits to be offered: 20</b>

III SEMESTER

1	Ethology & Evolutionary Biology- Hard Core -10	4	0	0	4
2	Applied Zoology – Hard Core – 11	3	0	1	4
3	Advanced Developmental Biology - Hard Core – 12	3	0	1	4
4	Molecular Endocrinology – Hard Core – 13	3	0	0	3
5	Genetic Engineering & Biotechnology - Soft Core – 5*	3	0	1	4
6	Adaptation Biology- Soft Core – 6*	3	1	0	4
7	Reproductive Health – Open Elective-3	3	1	0	4
<b>*Any one soft core to be opted</b>					<b>Minimum credits to be offered: 18</b>

IV SEMESTER

1	Environmental Biology – Hard Core – 14	3	0	1	4
2	Advanced Cell Biology - Hard Core – 15	4	0	0	4
3	Major Project - Soft Core – 7*	0	2	6	8
4	Research Methodology - Soft Core – 8*	3	1	0	4
5	Medical & Environmental Impact of Developmental Genetics - Soft Core – 9*	3	1	0	4
6	Biodiversity & Wildlife Biology - Soft Core – 10*	3	1	0	4
7	Economic Zoology– Open Elective-4	3	1	0	4
<b>*Either major project (7*) or any two other soft cores to be opted.</b>					<b>Minimum credits to be offered: 18</b>

Total Credits Offered: Hard Core-52 (minimum requirement: 42)

Soft Core- 44 (minimum requirement: 16)

Open Elective- 16

Total credits required for completing M.Sc. Program: 76 (including 52 credits from hard cores , 20 credits from soft cores and minimum 4 credits of open elective from other subjects,).

Maximum credits per semester=24, Minimum credits per semester =18

Chairman, BOS in Zoology

**M. Sc. ZOOLOGY I SEMESTER**  
**HARD CORE 1: NON-CHORDATA**

**48 Hrs**

**UNIT - I: Animal Taxonomy and Systematics:**

**12 Hrs**

- a. Introduction to taxonomy – Principles, stages, importance and rise of taxonomy.
- b. Taxonomic Procedures – Traditional or evolutionary method, Phonetic and Cladistic Methods.
- c. Taxonomic collections, identification and description; Taxonomical hierarchy (Linnean hierarchy); Vertical and Horizontal Classification; Concepts of Taxon, holotype, paratype, topotype etc.
- d. ICZN regulations and Zoological Nomenclature including use of suffixes ‘i’, ‘orum’, ‘ae’, ‘arum’, ‘ensis’ and ‘iensis’. oidea, idea, inae,; Tautonyms, synonyms and Homonyms.
- e. Concept of species- Different Species concepts, sub-species and other intra-specific categories.
- f. New trends in taxonomy: Ecological, Ethological, Cytological and Biochemical approaches and Numerical taxonomy.
- g. Molecular basis of animal taxonomy- DNA hybridization, Restriction analysis and sequencing of nucleotides.

**UNIT – II: Coelom , Nutrition and Locomotion:**

**12 Hrs**

- a. Origin and importance of Coelom: Acoelomates and Pseudocoelomates; Coelomates - Protostomia and Deuterostomia.
- b. Locomotion - Flagella and ciliary movement in Protozoa. Hydrostatic movement in Coelenterata, Annelida and Echinodermata.
- c. Patterns of feeding and digestion in lower metazoa; Filter feeding in Polychaeta, Mollusca and Echinodermata

**UNIT – III: Respiration, Excretion and Nervous system**

**12 Hrs**

- a. An overview of patterns of respiration in Invertebrates; Emphasis to be given to organs of respiration like Gills, Book-lungs and trachea and Respiratory pigments in Invertebrates
- b. An overview of patterns of excretion in Invertebrates; Emphasis to be given to organs of excretion: Coelomoducts, Nephridia and Malphigian tubules, Cocal glands.
- c. Primitive nervous system: Coelenterata and Echinodermata; Advanced nervous system: Annelida, Crustacea and Insecta) and Cephalopoda, Trends in neural evolution.

**UNIT – IV: Development and Paleontology**

**12 Hrs**

An overview of patterns of reproduction in Invertebrates; Direct and Indirect developments; Larval forms of free living and Parasitic invertebrates, Strategies and Evolutionary significance of larval forms; Fossils: Formation, Types and importance of fossils and an overview of Geological Time Scale

**Practical: NON-CHORDATA****16X2=32 Hrs**

1. Study of Nervous system : Crab, Sepia / Loligo	<b>2x1</b>
2. Study of mounting of Nephridium and Spermatheca in Earthworm	<b>2x1</b>
3. Study of Respiratory system: Mounting of Gills, Trachea and Booklungs	<b>2x1</b>
4. Protozoa : Gregarines, Monocystis, Ceratium, Euplotes, Didinum, Noctiluca, Radiolaria, Stentor, Opalina	<b>2x1</b>
5. Porifera : Sectional view of <i>Sycon</i> (T.S., L.S.) Grantia (T.S.)	<b>2x1</b>
6. Cnidaria : Obelia polyp and medusa, Pennaria, <i>Aurelia</i> –Tentaculocysts Virgularia, Spongodus, Zoanthus , Favia	<b>2x1</b>
7. Helminthes – Slides of Temnocephala, <i>Ascaris lumbricoides</i> . <i>Taenia solium</i> , <i>Planaria</i>	<b>2x1</b>
8. Annelida : Slides of Ozobranchus, Glossiphonia, Eunice, <i>Chloiea flava</i> , Polynoe, Terrebella, Eurythoe. Chaetopterus	<b>2x1</b>
9. Arthropoda – Balanus, Lepas. Palinurus, Uca, Pycna, Hippa, Gongylus. Belostoma Limulus, Squilla, Eupagurus	<b>2x1</b>
10. Mollusca – Museum specimens of Dolabella, Pteria, Nerita, Sanguinolaria, Lambis	<b>2x1</b>
11. Mollusca - Tridacna, Onchidium, Oliva, Murex, Turritella, Bulla, Cardium, Arca	<b>2x1</b>
12. Echinodermata – Echinodiscus, Holothuria and Antedon	<b>2x1</b>
13. Visit to campus – to study invertebrates in their natural forms	<b>2x1</b>
14. Visit to Earth Science Department – to study different fossils and GTS	<b>2x1</b>
<b>C1 assesment</b>	<b>2x1</b>
<b>C2 assesment</b>	<b>2x1</b>

**REFERENCES:**

1. Barrington, E J W, (1976): Structure and Functions of Invertebrates.
2. Barnes, RD, *Invertebrate Zoology*, Halt Saunders Intl. Edition
3. Hyman ,L.H, *The invertebrates (all volumes)*, McGraw Hill, Philadelphia, USA
4. Huston, AM, Biological Diversity, Cambridge University Press, Cambridge
5. Kapoor V.C, *Theory and Practice of Animal Taxonomy*, Oxford and IBH Publ., Delhi
6. McNeely ,JA, *Economics and Biological Diversity*, IUCN, Gland, Switzerland
7. Miller,S.A. and Harley,J.P. (2005). *Zoology*. 6<sup>th</sup> Ed.,McGraw Hill Higher Education, Boston, Toronto,Sydney
8. Prasad S.N, *Life of Invertebrates*, Vikas Publ. New Delhi
9. Sinha, A.K, Adhikari S and Ganguly BB, *Biology of Animals (vol. I & II)*,
10. Central Book Agency, Kolkata
11. Young ,J.Z. *Life of Vertebrates*, Clarendon Press, Oxford

**M. Sc., ZOOLOGY I SEMESTER  
HARD CORE 2: TRANSMISSION GENETICS**

**48 Hrs**

**UNIT I**

**12 Hrs**

- a. Mendel's principles of inheritance: The principles of dominance, segregation and independent assortment.
- b. Extensions of Mendelian principles: Allelic variations-a diagnostic test for alleles: Dominance: incomplete dominance, codominance, overdominance, pseudoalleles, multiple alleles, lethal alleles, penetrance and expressivity, pleiotropy; Interaction of genes: Epistasis, Suppressors; Polygenic inheritance; Phenocopy.

**UNIT II**

**12Hrs.**

- a. Fine structure of gene: Beadle and Tatum's One gene one enzyme concept, one gene one polypeptide concept, Complementation test, Intragenic complementation, Cistron, Recon and Mutton Eg. lz gene in *Drosophila* (Lozenge gene), rII locus in T4 phage.
- b. Sexlinked inheritance: In *Drosophila* and Humans, Inheritance of sex limited and sex influenced traits.
- c. Study of inheritance in haploid organisms- Neurospora, cross (tetrad analysis); Mitotic recombination.

**UNIT III**

**12Hrs**

- a. Linkage and crossing over: Chromosomal theory of inheritance; Concept of linkage- Experiments of Bateson and Punnett, Morgan's experiment ; Genetic recombination and construction of linkage maps in *Drosophila* ; Interference and coincidence
- b. Extranuclear inheritance: i) Organelle heredity-Chloroplast-Variation in 4'o clock plant; Mitochondria- Petite in *Saccharomyces*, ii) Maternal effect- Shell coiling in *Limnaea*, iii) Cytoplasmic Inheritance - *Paramecium* (Kappa Particle), iv), Infectious heredity - Sigma virus and *Wolbachia* bacterium in *Drosophila*.

**UNIT IV**

**12Hrs**

**Microbial Genetics:** (i) Conjugation: Discovery, nature of donor strains and compatibility, molecular mechanism of conjugation, Hfr, F (ii) Transformation: Discovery, Natural transformation systems, development of competence, Events involved in transformation (iii) Transduction: Discovery, generalized and specialized transduction, mechanism of generalized transduction, abortive transduction, mechanism of specialized transduction, sexduction.

## REFERENCES

- 1) Benjamin, A. Pierce. (2010): Genetics: A Conceptual Approach., 4<sup>th</sup> edition, W H Freeman & Co .
- 2) Brooker, R. J. (1999): Genetics: Analysis and Principles. Benjamin Cummings, Longman, INC.
- 3) Brooker, R. J. (2014) Genetics: Analysis and Principles. 5<sup>th</sup> edition. McGraw Hill.
- 4) Gardner E. J. M., Simmons, J.and Snustad, D.P.(1991): Principles of Genetics. John Wiley & Sons. INC. New York.
- 5) Gardner E. J. M., Simmons, J.and Snustad, D.P.(2006): Principles of Genetics. 8<sup>th</sup> edition. John Wiley & Sons. INC. New York
- 6) Griffiths,A.J.F., Wessler S.R., Lewontin, R.C, Gelbart W.M and Miller, J.H (2005): Introduction to Genetic analysis. W.H. Freeman and Company, New York.
- 7) Josh Dubnau (2014 ):Behavioral Genetics of the Fly. Cambridge University Press ,
- 8) Klug, W. S. and Cummings, M. R. (1994): Concepts of Genetics. MacMillan Colley Publishing and Company NY.
- 9) Klug, W. S. and Cummings, M. R.(2015): Concepts of Genetics. 11<sup>th</sup> edition. Pearson.
- 10) Markow T A and O'Grady P M. (2006): Drosophila- A guide to species identification and use. Elsevier Inc. Nertherlands
- 11) Simmons S. (2006): Principles of Genetics, 4<sup>th</sup> Edition, John Wiley & Sons (Asia) Pte Ltd. New Jersey.
- 12) Strickberger, M. W. (2000) Genetics. Mac Millan Publishing Co. NewYork
- 13) Strickberger M. W. (2012) Genetics. Mac Millan Publishing Co. NewYork
- 14) Tamarin, R H. (2009) Principles of Genetics. McGraw-Hill.
- 15) William S. Klug, Michael R. Cummings, Charlotte A. Spencer, and Michael Angelo Palladino. (2014): Concept of Genetics. Pearson College Division.

**M. Sc. ZOOLOGY I SEMESTER  
HARD CORE 3: CELL BIOLOGY**

**48 Hrs.**

**UNIT I**

**16 Hrs.**

**a. Overview of Cells and their functional specializations**

- i. Prokaryotic cells: Bacteria, Mycoplasma;
- ii. Eukaryotic specialized cells: RBC, muscle cells, neurons, Osteoblast

**b. Molecular architecture of eukaryotic cells**

- i. **Biomembranes** – composition, structure, fluid mosaic model.
- ii. **Basic functions of biomembrane:** permeability, osmotic principles, carrier proteins, channel proteins, passive transport, active transport, membrane pumps, multidrug resistance transport protein, pinocytosis, phagocytosis, receptor mediated endocytosis, transcytosis, electrical properties of membranes.
- iii. Integrating cells in to tissues: Cell junctions: occluding junctions, Anchoring junctions and communicating junctions, (Tight junctions, Desmosomes, Gap junctions), Cell adhesion: NCAM, Cadherins, fibronectins and integrins
- iv. Endoplasmic Reticulum (ER): Protein secretion, targeting proteins into ER, insertion of proteins into ER membrane, export of proteins and lipids from the ER, fate of misfolded proteins

**UNIT II Cellular organelles and their function**

**16Hrs**

- a. Mitochondria:** Ultra structure, inner membrane, transport proteins, synthesis and targeting mitochondrial proteins, biological energy transducers
- b. Lysosomes:** Lysosomal acid hydrolases, mechanism of membrane resistance to lysosomal enzymes, pathways and mechanisms of intracellular digestion, lysosomal secretion/defecation, lysosomal storage diseases
- c. Golgi complex:** Ultrastructural organization, protein glycosylation within Golgi, lipid and polysaccharide metabolism in Golgi, protein sorting and export from the Golgi. microbodies (Peroxisomes),
- d. Nucleus:** Nuclear envelope, nuclear pore complex, import and export between nucleus and cytoplasm, NLS, structure and function of Nucleolus (Ribosome factory)

- a. **Molecular mechanism of cell division:** i) Amitosis, Endomitosis and Mitosis ii) Ultra structure and organization of centrosome, centromere, Kinetochore, iii) Microtubules and their dynamic instability, Microtubule Associated proteins, Anaphasic movements, Cytokinesis
- b. **Chromatin organization:** (i) Molecular organization of Eukaryotic chromosome - Nucleosomes, Telomeres, Histone and Non-Histone proteins. ii) Chromosome Banding, Karyotyping and its importance
- c. **Heterochromatin:** Constitutive and facultative heterochromatin- Properties and functions, Gene silencing by heterochromatinization (telomeric effect).
- d. **Special chromosomes:** (i) Polytene chromosomes: Structural organization and significance. (ii) Lampbrush chromosomes: Structural organization and significance.
- e. **Chromosomal rearrangement:**
  - i) Structural rearrangements in chromosomes: (i) Deletions, Evolution by gene duplications, Inversion heterozygotes, Permanent structural (Translocation) heterozygosity. Ex. *Oenothera* , Centric fusion and Centric fission (ii) Practical applications of rearrangements- Balancers, Ring chromosomes, Attached X-chromosome in *Drosophila*.
  - ii) Numerical variations in chromosomes: (i) Aneuploidy – causes and consequences with examples from Man ( Trisomy 21 and sex chromosomal) (ii) Polyploidy – causes and consequences. Ex. *Raphanobrassica*, Wheat.

**REFERENCES:**

1. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
5. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.



**M. Sc. ZOOLOGY I SEMESTER**  
**HARD CORE 4: ANIMAL PHYSIOLOGY**

**32 Hrs**

**UNIT I: Transport across the membrane, Cellular Respiration & Bioenergetics** **8 Hrs**

- a. Molecular mechanisms of passive and active transport.
- b. i) Energy – Concept, laws of thermodynamics ii) Redox potential iii) Stepwise release of energy through cytochromes, production of ATP, uncoupling of oxidative phosphorylation, inhibitors iv) Anaerobic and aerobic breakdown of glucose, alternate pathway – HMP shunt and glucuronic acid pathway v) Citric acid cycle as common metabolic pathway.

**UNIT II: Circulation and Excretion** **8 Hrs**

- a. i) Major types of body fluids and their composition, ii) Neurogenic and myogenic hearts iii) Mammalian heart – cardiac cycle, ECG.
- b. i) Nitrogenous waste products in animals ii) Formation of ammonia, urea and uric acid. iii) Nitrogen excretion in relation to water economy iv) Overview of urine formation in mammals with emphasis on regulation of fluid volume, blood pressure, sodium levels and Acid-base balance.

**UNIT III: Muscle and Neurophysiology** **8 Hrs**

- a. Molecular organization of sarcomere ii) Mechanism of contraction with emphasis on sliding filament and Davies models, regeneration of storage phosphate iii) Physiological adaptations of muscles for jumping, swimming and flight.
- b. i) Electrochemical gradients – Nernst and Goldman equations ii) Axonal and synaptic transmission of nerve impulses iii) Synaptic integrity, synaptic plasticity iv) Molecular mechanism of sensory transduction and neural output in receptor cells.

**UNIT IV: Environmental Physiology** **8 Hrs**

- a. i) Concept of homeostasis, Regulators and conformers ii) Tolerance, resistance acclimation and acclimatization iii) Overview of thermal homeostasis in homeotherms, CNS regulation of body temperature maintenance iv) Temperature compensation in poikilotherms
- b. Overview of osmoregulation in aquatic and terrestrial animals
- c. Stress: Metabolic and immunological responses.

## PRACTICAL: ANIMAL PHYSIOLOGY

4x16 = 64 Hrs

1. Estimation of blood glucose content.	1x4
2. Estimation of glycogen in liver	2x4
3. Determination of Blood cholesterol content.	1x4
4. Determination of Iodine number of fats to evaluate the biological value.	1x4
5. Total count of RBC and WBC.	2x4
6. Differential count of WBC.	1x4
7. Determination of serum phosphatase activity.	2x4
8. Estimation of blood urea content.	2x4
9. Determination of serum acetylcholine esterase activity.	2x4
10. Estimation of RNA concentration by Diphenylamine method.	1x4
11. Estimation of serum LDH activity.	1x4

Note: All estimations with Clinical /slaughter house Samples

### REFERENCES

1. Guyton, A.G. (2002). Text Book of Medical Physiology, 12<sup>th</sup> Edn. Saunders Publication.
2. Hoar, W.S. (1983). General and Comparative Animal Physiology, 3<sup>rd</sup> Edn. Prentice Hall Inc.
3. Jayaraman, J. (1981). Laboratory Manual in Biochemistry, Wiley Eastern Ltd.
4. Murray, R.K., Garner, D.K., Mayes P.A. and Rodwell, V.W. (2003). Harper's Illustrated Biochemistry, 26<sup>th</sup> Edn. Lange Medical Books, McGraw Hill, New York.
5. Plummer, D.T. (1988). An Introduction to Practical Biochemistry. Tata McGraw Hill Publishing Company, Ltd. New Delhi.
6. Randal, D., Burggren, W. and French, K. (2002). Eckert Animal Physiology, Mechanisms and adaptations. 4<sup>th</sup> Edn. W. H. Freeman and Company, New York.
7. Schmidt-Nielsen, K. (2002). Animal Physiology: Adaptations and Environment, 5<sup>th</sup> Edn. Cambridge University Press, UK.
8. Tyagi, V.K. (2005): Animal Physiology and Biochemistry. Kedar Nath Ram Nath, New Delhi, Meerut.

**M. Sc. ZOOLOGY I SEMESTER**  
**HARD CORE 5: PRACTICAL: CYTOGENETICS**

**16x4=64Hrs**

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|---|-----|
| 1. Study of Life cycle, culture and maintenance of <i>Drosophila melanogaster</i> .   | 1x4 |
| 2. Study of Morphology (wing, sex comb, genital plate and bristles) of<br><i>Drosophila melanogaster</i>  | 2x4 |
| 3. Study of mutants of <i>Drosophila melanogaster</i> – Dominant, Recessive,<br>Autosomal, Sex-linked and Multiple mutations  | 2x4 |
| 4. Genetic crosses and analysis of P <sub>1</sub> , P <sub>2</sub> , F <sub>1</sub> , F <sub>2</sub> & test cross progeny in<br><i>Drosophila</i> :(a) Monohybrid (b) Dihybrid (c) Sex-linked inheritance | 3x4 |
| 5. Study of Polytene chromosomes of <i>Drosophila melanogaster</i>  | 2x4 |
| 6. Study of inversion heterozygotes in <i>D.ananassae</i>   | 1x4 |
| 7. Study of meiotic stages and chromosome anomalies in grass hopper testis  | 3x4 |
| 8. Study of Barr body using buccal smear of volunteers  | 1x4 |
| 9. Observation of mitochondria using Janus green stain  | 1x4 |

**M. Sc. ZOOLOGY I SEMESTER**  
**SOFT CORE 1: BIOLOGICAL CHEMISTRY**

**32 hrs**

**UNIT – I : Foundations of Biochemistry and Techniques in biochemistry** **08**

- a. Structure of atom and molecules
- b. Stabilizing interactions – Vandervaal's, electrostatic, hydrogen bonding, hydrophobic interactions.
- c. Principles of bio-physical chemistry –pH, buffer, reaction kinetics, molarity, normality
- d. Principle and Types of Chromatography; Principle, method and application of Ion exchange and HPLC.
- e. Principle, method and applications of NMR spectroscopy, Flow cytometry and ELISA

**UNIT –II Carbohydrates and lipids** **08**

- a. Carbohydrates – an overview of chemistry and classification, stereochemistry- D and L isomers, epimer, chair and boat conformations, cyclic structure.
- b. Lipids – an overview of chemistry and classification, fatty acid synthesis & breakdown, blood lipid profile & its impact on health, steroids – Types and out lines of biosynthesis, eicosanoids- types.

**UNIT – III Proteins and Nucleic acids** **08**

- a. Primary structure – determination of protein structure, Anfinsen's experiment, Secondary structure - alpha helix, beta sheets (dihedral angles, circular dichroism, Ramachandran plot, tertiary and quaternary structures, protein folding and denaturation, misfolding (Prion).
- b. Nucleic acids – chemistry, types and structural organization, alternate models, cyclic nucleotides – chemistry and biosynthesis.

**UNIT – IV Enzymes and Vitamins** **08**

- a. Enzymes – Nomenclature and Classification, Mechanism of enzyme action, Enzyme inhibition, Factors affecting enzyme catalyzed reactions, abzymes, ribozymes, isozymes
- b. Vitamins: Classification; sources, effects and deficiency diseases of water soluble and fat soluble vitamins; vitamins as co-enzymes; Trace elements and significance in nutrition.

## PRACTICAL: BIOLOGICAL CHEMISTRY

4x16=64 Hrs

- |  |       |
|--|-------|
| 1. Colorimetry: Theoretical aspects of colorimetry and Spectrophotometry to be Explained.<br>Determination of absorption maxima using dye solutions.<br>Demonstration of Beer-Lambert's law. | 2x4   |
| 2. Thin layer chromatography of a plant extract.   | 1x4   |
| 3. Demonstration of gel electrophoresis (Proteins).  | 2x4=8 |
| 4. Preparation of osazones and identification of carbohydrates.  | 2x4   |
| 5. Test for non esterified fatty acid  | 1x4   |
| 6. Colour reactions of albumin.  | 2x4   |
| 7. Estimation of amino acids by Sorenson's formal titration.   | 1x4   |
| 8. Estimation of Proteins by Lowry et al method.   | 2x4   |
| 9. Effect of enzyme concentration on rate of enzyme catalyzed reaction   | 1x4   |
| 10. Effect of temperature on rate of enzyme catalyzed reaction   | 1x4   |

## REFERENCES

1. Conn, E. E., Stumpt, P. K., Bruencing, G. and Dol, R. G. (1995). Outlines of Biochemistry. John Wiley, Singapore.
2. Harper, H. A. (1993). A review of Physiological Chemistry, 2<sup>nd</sup> Edn. Lange Medical Publication,
3. Lehninger, A. L., Nelson, D. L. and Cox, M. M., 2<sup>nd</sup> Edn. (1993.). Principles of Biochemistry, CBS Publishers and Distributors, New Delhi.
4. Oser, B. L. (Ed.) 1993. Hawk's Physiological Chemistry. Tata Mc Graw Hill Publishing Co. Ltd. New Delhi.
5. Plummer, D. T. (1993). Practical Biochemistry, 3<sup>rd</sup> Edn. Tata Mc Graw Hill Publishing Co., Ltd. New Delhi.
6. Wilson, K. and Walker, J. principles and Techniques in Practical Biochemistry. (1995). 4<sup>th</sup> Edn. Cambridge University Press, Cambridge, U. K.

**M.SC. ZOOLOGY I SEMESTER**  
**SOFT CORE 2: VECTORS AND COMMUNICABLE DISEASES** **48 Hrs**

**UNIT I. Introduction to vector biology;** **12 Hrs**

- a. Scope and importance of vectors:
- b. Historical perspective – epidemics, scientists involved in the discovery of vectors and pathogens of communicable diseases.
- c. Bio-ecology and life cycle of vectors.
- d. Vector-parasite interaction; Host-pathogen interaction, insect transmitting bacteria and viruses.

**UNIT II. Biological vectors and Communicable diseases** **12 Hrs**

- a. Epidemiology and biology of vectors and pathogens,
- b. Transmission cycles and symptoms of malaria, filariasis, yellow fever, leishmaniasis, anthrax, dengue, chikungunya, Japanese encephalitis, schistosomiasis and plague.

**UNIT III. Mechanical vectors** **12 Hrs**

- a. House flies, cockroaches and bedbugs – Transmission of dysentery, diarrhea, typhoid cholera, epidemic conjunctivitis and skin infections.
- b. Nematodes: Ancylostoma, Ascaris, Enterobius & Wuchereria
- c. Ticks: Morphology and life history of : Argas and Haemaphysalis

**UNIT IV. Control of vectors and vector borne diseases** **12 Hrs**

- a. Cultural control methods, chemical methods, genetic and environmental methods, biological methods using microbes and predators. Integrated Vector Control and Management (IVCM).
- b. Insecticide resistance in vectors, Drug resistance in pathogens.
- c. Importance of education, awareness and community participation.

**TUTORIAL: VECTORS AND COMMUNICABLE DISEASES** **2x16=32Hrs**

Tutorials to include brain storming sessions, discussions and seminar presentations.

## REFERENCES:

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2. Cedric, G. (1995). Entomology. Plenum Press, New York and London.
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## M.SC. ZOOLOGY II SEMESTER

### HARD CORE 6: CHORDATA

48 Hrs

#### UNIT I. Origin and interrelationships

12 Hrs

- a. General characters and outlines of classification of Chordata - the construction and interpretation of classifications. Origin of chordates in the light of recent theories.
- b. Fine structure and role of notochord and endostyle in Amphioxus and Ascidia with their evolutionary significance.
- c. General characters and classification of Protochordata.. Phylogenetic interrelationship between Protochordates and Chordates.
- d. Reproduction in Tunicates and significance of retrogressive metamorphosis.
- e. The Nature of Vertebrate Morphology – Definition, Scope and Relation to other disciplines; Importance of the study of vertebrate morphology.
- f. Some principles and considerations. Origin and Classification of Vertebrates.

#### UNIT II. Vertebrate Integument, Excretory system, Nervous system and Sense organs

12 Hrs

- a. Development and general structure of skin and its functions; Integument of fishes with emphasis on dermal derivatives; Integument of Tetrapods with emphasis on epidermal derivatives - glands, scales, horns, claws, nails, hoofs, feathers and hairs.
- b. Excretion- Evolution of uro-genital system in Vertebrates; Comparative account of kidney in Vertebrates.
- c. Nervous system: Development of spinal cord and peripheral nervous system; Evolution of spinal nerves, cranial nerves and autonomic nervous system; Development and organization of the brain; Comparative account of brain in Vertebrates.
- d. Sense organs: Types of receptors; Organs of olfaction and taste- Vomero-nasal/Jacobson's organ in reptiles; lateral line system; electroreception in fish; ear and eyes in Vertebrates.

#### UNIT III. Respiration, circulation and locomotion:

12 Hrs

- a. Structure and mechanism of cutaneous, branchial and pulmonary respirations.
- b. Outline of origin and evolution of cardiovascular system in vertebrates.
- c. Form, function, size and skeletal and muscular elements of the body –Appendicular skeleton – origin of tetrapod limbs and their modifications. Appendicular musculature of Tetrapodes.
- d. Axial skeletons- Overview of Skull Morphology, Skull Function and Design. Origin of Jaw and modification of Jaw bones and types. Functional and evolutionary significance of Jaw suspension in Vertebrates. Origin and evolution of Webbarian ossicles in fish and ear ossicles in mammals.
- e. Types of vertebrae of Procoelus, Opisthocoelus, Amphicoelus, Amphiplatins, Heterocoelus, Axis and atlas vertebrae.



- f. Types of Vertebrate musculature. Flight muscles of Birds; Skeletal and muscular elements in Running and jumping; Digging and crawling without appendages; Climbing; Swimming, diving , Flying and Gliding.

#### UNIT IV. Adaptive radiation in Vertebrates

12 Hrs

Origin, evolution and adaptive radiation in fishes, amphibians, reptiles, birds and mammals.

#### PRACTICAL: CHORDATA

2x16=32

1. Study of Digestive, Reproductive, Respiratory, Arterial and venous systems in different vertebrates . 2x4

Study of museum specimens and slides with emphasis on evolutionary and adaptive significance:

2. Protochordates – Salpa-sexual, Salpa-asexual, Botryllus, Herdmania 2x1
3. Fishes – *Rhinobatus*, *Chimera*, *Acipenser*, *Amia*, *Periophthalmus*, *Triacanthus*, *Notopterus notopterus*, *Scatophagus argus*, *Trichiurus*, *Mastacembalus armatus*, *Exocoetus* (flying fish), *Diodon hystrix*, *Echeneis naucrates*. *Zygaena*, *Pristis*, *Narcine*, *Trygon*, *Rhinobatus*, *Chimaera*. Actinopterygii : *Polypterus*, *Lepidosteus*, *Muraena*, *Mystus*, *Catla*. *Hippocampus*, *Syngnathus*, , *Anabas*, *Diodon*, *Tetradon*, *Echeneis*. 2x2
4. Amphibians – *Ichthyophis*, *Geganocephalus*, *Rhachophorus*, *Rana tigrina*, *Amblystoma*, *Uraeotyphlus*, *Necturus*, *Amphiuma*, *Ambystoma* and its Axolotllarva. *Triton*, *Salamandra*, *Hyla*, *Rhacophorus*. 2x1
5. Reptiles – *Sitana*, *Chameleon*, *Phrynosoma*, *Chelone mydas*, *Hemidactylus*, *Calotes*, *Draco*, *Varanus*, *Phrynosoma*. *Typhlops*, *Python*, *Eryx*, *Ptyas*, *Bungarus*, *Naja*, *Hydrus*, *Vipera*, *Crocodylus*. *Gavialis*, *Chelone* and *Testudo*. 2x2
6. Birds – Indian Oriole, Indian koel - male & female, Indian tailor bird, kite, jungle fowl. 2x1
7. Mammals – Indian otter, Marmoset, Loris Bat – *Megaderma lyra*, Pangolin. 2x1
8. Osteology - Skull and lower jaw of *Chelonia*, Crocodile, Bird, Carnivore mammal (dog), Herbivore mammal (horse); Types of vertebrae of Procoelus, Opisthocoelus, Amphicoelus, Amphiplatin, Heterocoelus, Axis and atlas vertebrae. 2x4

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**M.SC. ZOOLOGY II SEMESTER  
HARD CORE 7: REPRODUCTIVE BIOLOGY**

**48 Hrs**

**UNIT – I Sex differentiation and Female reproductive organs: 12 Hrs**

- a. Origin and migration of primordial germ cells; genetic and hormonal control of differentiation of gonads and gonadal ducts in mammals. (4 hrs)
- b. Female Reproductive System-Functional morphology of mammalian ovary, Fallopian tube and uterus. (2 hrs)
- c. Hormonal control of follicular development – Recruitment and selection of follicles, Follicular dominance, Oocyte maturation, Ovulation, Atresia and Regulation of corpus luteum. (6 hrs)

**UNIT – II Female reproductive physiology: 12 Hrs**

- a. Onset of puberty in human, factors affecting onset of puberty
- b. Estrous cycle and its hormonal regulation
- c. Menstrual cycle and its hormonal regulation
- d. Fertilization – Molecular Events of fertilization
- e. Implantation – Process, Types and hormonal control
- f. Pregnancy – length of gestation, hormonal control
- g. Parturition – Process of birth and influence of hormones
- h. Lactation – Hormonal control of mammary gland development and lactogenesis

**UNIT – III Male reproductive physiology 12 Hrs**

- a. Functional morphology of mammalian testis
- b. Brief description of histomorphology and hormonal control of male accessory organs viz., epididymis, vas deferens, seminal vesicles, ventral prostate, bulbourethral gland and preputial gland
- c. Sperm maturation – morphological and biochemical events, influence of accessory organ secretions; capacitation
- d. Biochemistry of semen
- e. Kinetics of spermatogenesis – wave and cycle, Stem cell renewal
- f. Hormonal control of spermatogenesis
- g. Ultrastructure of spermatozoa
- h. Abnormalities of sperm

**UNIT – IV Fertility control and assisted reproduction (ART) 12 Hrs**

- a. Fertility control: Need, principles, practice and efficacy of different male and female temporary and permanent contraceptive methods- hormonal and barrier methods; intrauterine devices and sterilization. (6 hrs)
- b. Assisted Reproduction: Ovulation induction, Sperm bank, Artificial insemination, different methods of assisted reproduction – *In vitro* fertilization (IVF), gamete intrafallopian transfer (GIFT), Zygote intrafallopian transfer (ZIFT), intracytoplasmic sperm injection (ICSI), pre-implantation genetic diagnosis (PGD), Surrogacy. Ethical and legal considerations of ART and PGD. (6 hrs)

**M.SC. ZOOLOGY II SEMESTER  
HARD CORE 8  
PRACTICAL: REPRODUCTIVE BIOLOGY & HISTOLOGY 64hrs**

**I. Reproductive Biology: 8x4=32 hrs**

- a. Study of estrous cycle in rat using vaginal smear. 4x2= 8 hrs
- b. Staining of vaginal smear in laboratory rat. 4x1=4 hrs
- c. Sperm count and study of sperm abnormalities in semen samples collected from volunteers / clinical samples. 4x2=8 hrs
- d. Study of different contraceptive devices 4x1=4 hrs
- e. Observation of permanent slides 4x2=8 hrs
  - i. Comparative morphology of ovary in vertebrates
  - ii. Comparative morphology of testis in vertebrates

**II. Histology: 8x4=32 hrs**

- a. Microtomy and staining: Hematoxylin-eosin – Demonstration 4x3=12 hrs
- b. Functional histology: Observations of permanent histology slides of mammalian organs: stomach, intestine, spleen, liver, kidney, lungs, thymus, blood vessel, lymph vessel, brain, bone and bone marrow. 4x2=8 hrs
- c. Histopathology : Study of histopathological changes (permanent slides): Gastric ulcers, Cirrhosis of liver, Breast tumors, Cystic follicles of ovary, Pancreas in diabetes, Cryptorchid testis and leukemia. 4x2=8 hrs
- d. Histochemistry: Localization of proteins and ( Bromophenol blue method) and PAS reaction 2x2 = 4 hrs

## REFERENCES

1. Adler N. T (1981): Neuroendocrinology of Reproduction, Physiology and Behaviour.
2. Austin, C. R and R. V. Short (eds) (1972) Reproduction in mammals. (1) Germ cells and Fertilization, (2) Embryonic and Foetal development, (3) Hormones in Reproduction, (4) Reproduction patterns (5) Artificial control of reproduction, Cambridge University press, London.
- 3.. Chester-Jones, I. Ingleton, P. M. and Philips, J. G. (1987) Fundamentals of comparative vertebrate endocrinology. Plenum press, N. Y
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10. Rodolfo Rey, Nathalie Josso, and Chrystele Racine (2016): **Sexual Differentiation** E-book

**M.SC. ZOOLOGY II SEMESTER  
HARD CORE 9: MOLECULAR BIOLOGY**

**48 hrs**

**UNIT I**

**8 Hrs**

- a. Introduction to Nucleic acids:** a) Nucleic acids store and convey genetic information, Information transfer– Central Dogma – b) Overview of structure of: DNA: The double helix Complementarity of bases
- b. Replication of DNA:**
1. Enzyme and non enzyme components of replication machinery
  2. Replication process: i) Initiation of replication: Origin of replication, DnaA, Regulation of initiation in relation to cell division. ii) Elongation: coordinated synthesis of Leading and Lagging strands. iii) Termination: End replication problem- telomerase in eukaryotes
  3. Fidelity in replication: Selection, proof reading, mismatch repair.

**UNIT II**

**8 Hrs**

- a. DNA Repair** i) Direct reversal of DNA damages: Photoreactivation, Alkyl transferases (ii) Excision repair: Nucleotide excision-Uvr ABC system, Base excision and AP nuclease pathway (iii) Transcription coupled repair (iv) SOS repair (v) Translesion synthesis.
- b. Recombination:** Homologous recombination: (i) Models of Recombination - Holliday model, Double strand break model, Genetic consequence of homologous recombination. (ii) Protein Machinery and mechanism of homologous recombination.

**UNIT III Transcription:**

**8 Hrs**

- (a) cis components Template, promoter, (b) RNA polymerases (c) Transcription mechanism-Initiation, Elongation and Termination in Prokaryotes and Eukaryotes (d) Post transcriptional modifications of transcripts (i)Prokaryotes: mRNA, rRNA, tRNA. (ii) Eukaryotes: mRNA (G-cap, Poly-A tail, Splicing)

**UNIT IV Translation:**

**8 Hrs**

- (i) Genetic code: genetic and biochemical analysis of genetic code, features of Genetic code, (ii) Enzymes of translation: AminoAcyl tRNA synthetase, Peptidyl transferase (iii) Translation process and factors: initiation, elongation (selection against incorrect Amino Acyl tRNA), and termination

**UNIT V Gene Regulation in Prokaryotes**

**8hrs**

- a. Transcriptional Regulation:** i) Cis acting elements: Operator, enhancers, Silencers, Trans factors - Activators, Repressors, DNA binding motifs, helix turn helix, Zinc finger, Leucine Zipper ii)The Operons - Lactose operon (Allosteric, positive, negative control), iii) Regulation in Lambda Phage - Lytic and lysogenic cycle (Logic of lambda)

- b. Regulation beyond transcription initiation,** i) premature termination of transcription - Tryptophan operon (*trp* attenuator) ii) Ribosomal proteins as translational repressors (iii) Riboswitches (B12).

**UNIT VI Gene Regulation in Eukaryotes:**

**8hrs**

- a. Transcriptional Regulation** i) Basic considerations, Britten and Davidsons model ii) Transcriptional activators: Recruit transcription machinery proteins and nucleosome modifiers (HATs & DMTs), Example: Yeast Mating type switching iii) Transcriptional repression : Mechanism - Competition, inhibition, direct repression, indirect repression,
- b. Regulation after transcription initiation:** i) Alternative mRNA splicing (Reliable recognition of splice sites, ESE & ESS sequences, SR proteins), Mechanisms (Exon skipping etc) and significance examples *sxl* , *tra* and *dsx* in flies ii) Translational control as in Ferritin and transferrin mRNA, iii) RNA interference miRNA and siRNA with examples

**Practical: MOLECULAR BIOLOGY AND EVOLUTION 8X4=32**

1. DNA isolation by rapid method	1X4
2. Estimation of DNA concentration by Diphenylamine method	1X4
3. Demonstration of PCR	1X4
4. Karyotyping	1X4
5. Study of mitotic chromosomes of <i>D. melanogaster</i>	1X4
6. Study of sympatric species- <i>D. melanogaster</i> and <i>D. ananassae</i>	1X4
7. Study of few examples of homologous and analogous organs	1X4
8. Experiment to demonstrate Genetic drift and Natural Selection	1X4

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2. Lewin, B (2003): Genes VIII. Oxford University Press. Oxford.
3. Lodish, Berk, Kaiser, Krieger, Scott, Bretscher, Ploegh and Matsudaira, (2007). *Molecular Cell Biology, 6th Edition.*
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**M.SC. ZOOLOGY II SEMESTER**  
**SOFT CORE 3: HISTOLOGY AND HISTOPATHOLOGY**

**48 Hrs**

**UNIT I Tissue fixation and staining**

12Hrs

- a. Histology, Histochemistry and Histopathology: Meaning, objectives and applications.
- b. Tissue fixation: Objectives, methods, chemical fixatives-types and chemistry of fixation; Physical methods - freezing and microwave fixation; choice of fixatives, factors affecting fixation, fixation artifacts.
- c. Dyes – Classification, Natural and Synthetic,

**UNIT II Histology :**

12Hrs

- a. Epithelium: Types and modifications – cilia, microvilli, stereocilia, flagella, junctional complexes.
- b. Functional Morphology (mammalian): lungs, kidney, spleen, thymus, brain, bone and bone marrow, blood and lymph vessels.

**UNIT III Histochemistry:**

12Hrs

- a. Classical Histochemistry:  
Principles and methods of application and utility of classical histochemical techniques :  
Examples: Localization of glycoproteins (PAS), nucleic acids (Feulgen) and steroid dehydrogenase activity.
- b. Immunohistochemistry:  
Principles and methods of application of Immunohistochemistry and immunofluorescence techniques. Examples: Localization of proteins in endocrine cells (Pituitary cell types or islet of Langerhans); *In situ* hybridization of nucleic acids.

**UNIT IV Histopathology:**

12 Hrs

- a. Morphological alterations in cells due to disease, types of degeneration-clouding, hyaline, hydrophic and fatty degeneration.
- b. Etiology, pathogenesis and histopathology of Liver cirrhosis and atherosclerosis, Neuropathology of alcoholism and methanol poisoning.
- c. Tumors- malignant and non-malignant, types of carcinoma, histopathology of breast and prostate tumors.

**REFERENCES:**

1. Boyd,W. 1976:A text book of Pathology. Structure and function in disease, 4th edition. Lea and Fibiger, Philadelphia.
2. Cotran,R.S.,Kumar, V.,and Robbins,S.L.(1989): Robbins Pathologic basis of Disease, 4<sup>th</sup> Ed.,W.B.Saunders Company,London,Sydney
3. Pearse, A.G.E. (1980): Histochemistry, theoretical and Applied ,J & A, Churchill Ltd., London.
4. Rogers, A.W.(1983): Cells and Tissues, An introduction to Histology and Cell Biology, Academic Press, NY.
5. Telford, I.R. and Bridgman,C.F.(1990). Introduction to Functional Histology, Harper and Row, NY.



**M.SC. ZOOLOGY II SEMESTER  
SOFT CORE 4: ADVANCED GENETICS**

**64 Hrs**

**UNIT I**

**16Hrs**

- a. Mutations:** (i) Mutations: Types of Mutation: Synonymous, Nonsynonymous, Nonsense, missense, frameshift mutations, Transition and Transversion. (ii) Reverse mutations (iii) Intragenic suppressors (iv) Lethal mutation (v) Loss of function mutation (vi) Gain of function mutation- Amorphic, hypomorphic and isoallelic mutations.
- b. Chemical mutagens:** (i) Base analogues (ii) Nitrous acid (iii) Hydroxylamine (iv) Hydrazine (v) Alkylating agents (vi) Detection of mutations – Ames test (2) *Drosophila*: Sex-linked recessive lethals, autosomal recessive lethals, dominant lethal test
- c. Sex determination and dosage compensation**
  - i) Chromosomal basis of sex determination: (i) Simple systems: Eg: XX/XY, XX/XO, ZZ/ZW (ii) Parthenogenesis: Ex. Honey bees. (iii) Molecular basis of sex determination in *Drosophila* and Man (iv) Molecular basis of dosage compensation in *C. elegans*, *Drosophila* and Man.

**UNIT II Epigenetics**

**16 hrs**

- a.** Introduction to concept and definition of Epigenetics, Epigenetic Landscape (Waddington)
- b. Imprinting of Genes, Chromosomes and Genomes:** i) Discovery- Pronuclear transplantation experiments in mouse, (ii) Sex determination in Coccids (iii) H19/IGF2 (reciprocal imprinting) in mammals
- c. Molecular basis of epigenetics**
  - i. Histone & DNA modifications (acetylation, deacetylation, methylation, Histone phosphorylation, ‘Histone Code’),
  - ii. Role of Non-coding RNAs in gene regulation eg. X-chromosome inactivation in mammals,
  - iii. Chromatin remodeling and differential gene regulation by Polycomb and Trithorax proteins.
  - iv. Epigenetic reprogramming: Epigenome, Epigenotypes (Twins, Age related, diseases )

**Unit III Genomics**

**16 Hrs**

- a. Mapping of genomes:** (i) Genetic mapping- (1) Cross breeding and pedigree analysis (2) DNA markers - RFLPs, SSLPs, SNPs. (ii) Physical mapping - Restriction mapping, Fluorescent *in situ* hybridization, Radiation hybrid mapping and Sequence tagged site mapping.

- b. Structural genomics:**(i) Assembly of a contiguous DNA sequence- shotgun method, clone contig method, and whole – genome shotgun sequencing. (ii) Understanding a genome sequence: locating the genes in a genome sequence, determining the functions of individual genes
- c. Functional genomics:** Study of transcriptome (By sequence analysis, and Microarray analysis) and Proteome (Interacting proteins by phage display and Yeast two hybrid system)
- d. Comparative genomics:** Bacteria (*H. influenzae*), organelles, eukaryotes (Yeast,*Caenorhabditis elegans*, *Drosophila*, *Arabidopsis*, Human).

#### UNIT IV Human Genetics:

16 Hrs

- a.** History, Construction and analysis of Pedigrees, Pattern of inheritance.
- b. Genetic basis of syndromes and disorders:**(1)Monogenic diseases (i) Autosomal dominant ( Huntington disease) (ii) Autosomal recessive (Cystic fibrosis ) (iii) Inborn errors of metabolism (Phenylketonuria) (iv) Genetic disorders of Haemopoietic systems (Sickle cell anemia) (v) X linked disorders (vi)Genetic disorders of eye (colour blindness ) (vii) Muscle genetic disorders (Duchenne Muscular Dystrophy) (2) Genome imprinting syndromes (Prader-Willi & Angelman syndromes) (3) Chromosomal disorders (aneuploidy, structural variations) (4) Mitochondrial disorders (5) Multifactorial disorders ( diabetes, Obesity) (6) Polygenic congenital heart diseases (7) Cognitive disabilities (Schizophrenia) (8) Neurogenetic disorders (Parkinson disease) (9) Genetics of reproduction
- c. Diagnosis, Counseling, Therapy and Ethics:** (a) Prenatal diagnosis: (1)Noninvasive methods- X- radiation, Ultrasonography and Fetal echocardiography (2) Invasive methods- Maternal serum screening, Amniocentesis, Chorionic villus sampling and Fetoscopy (b)Technology in reproductive assistance (c) Genetic counseling: (d) Risk assessment and counseling in Mendelian and multifactorial syndromes (e) Gene therapy (f) Genome editing (g) Eugenics, human genetics and legal, social and ethical considerations.

## REFERENCES

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13. The *Caenorhabditis elegans* genome 1998. Science Vol. 282.
14. The Arabidopsis Genome, 2000 Nature vol. 408.

**M.SC. ZOOLOGY II SEMESTER**  
**OPEN ELECTIVE 1: PRINCIPLES OF ANIMAL SCIENCE**

**48 Hrs**

**UNIT I. Introduction and Animal Taxonomy:**

5 Hrs

- a. Characteristics of animals
- b. Branches of animal science
- c. Uniqueness of Indian Wildlife
- d. Animals as natural resource and their Conservation.
- e. Animals and human welfare.
- f. Variety of life (different Kingdoms)
- g. Carl Linnaeus – Taxonomic hierarchy, Binomial nomenclature
- h. Major and minor phyla – diagnostic features with example for each phylum

**UNIT II Biomolecules, Animal cells and Tissues:**

7 Hrs

- a. Chemical composition
- b. Examples and importance of carbohydrates, lipids, proteins, nucleic acids, enzymes and hormones
- c. Sources and function of vitamins
- d. Cell theory
- e. Brief description of animal cell (light and ultra structure)
- f. Functions of cell organelles
- g. Structure and functional diversity in animal cell
- h. Cell division
- i. Structure and functions of basic tissues.

**UNIT III Organ systems: Structure and functions:**

18 Hrs

- a. Nutrition: Feeding mechanisms in animals – filter feeding, biting and chewing, piercing and sucking, detritus feeding. Human alimentary canal and outlines of digestion and absorption
- b. Respiration : Respiratory devices in different habitat, Human respiration – exchange of gases, cellular respiration, and ATP synthesis
- c. Circulation : Blood vessels and capillaries, composition of blood, blood coagulation, immunity
- d. Excretion : Nitrogenous waste productions, excretory organs in animals, mammalian kidney and urine formation
- e. Movement : Locomotion in vertebrates – Swimming, walking running, flying skeletal muscle contraction
- f. Co-ordination : Neural and chemical co-ordination, parts of nervous system and their functions, endocrine system and hormones as chemical messengers
- g. Reproduction : Asexual and sexual reproduction, significance of sexual reproduction, outlines of human reproduction and fertility control

**UNIT IV Ecology and Environmental Biology:**

8 Hrs

a) Abiotic and Biotic factors b) Population ecology c) Environment and Micro organisms (microbial ecology) d) Environmental Pollution – brief account of Air, Water, Noise, Pesticide, Metal, sound and soil pollution.

**UNIT V Heredity and Evolution:**

6 Hrs

a) Continuity of life – Mendel's laws b) Structure of chromosomes and genes c) DNA and RNA d) Central dogma in molecular biology d) Evolution: Major theories and Evidences

**UNIT VI Applied Zoology:**

4 Hrs

- a. Brief description, and economic importance of Vermiculture, Apiculture, Sericulture, Fishery, poultry, piggery and diary
- b. Vectors and human parasites.

**TUTORIAL: PRINCIPLES OF ANIMAL SCIENCE**

2x16=32 Hrs

Tutorials to include brain storming sessions, discussions and seminar presentations

**REFERENCES:**

1. Barnes, R. D. (1974): Invertebrate Zoology, III edition, W. B. Saunders Co., Philadelphia.
2. Barrington, E. J. W.( 1976):. Invertebrate structure and function. Thomas Nelson and Sons Ltd., London
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5. Russel Hunter, W.D (1969.). A. biology of higher invertebrates, Mac millon Co.,Ltd., London.
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8. Tyagi, V.K. (2005): Animal Physiology and Biochemistry. Kedar Nath Ram Nath, New Delhi,Meerut.

**M. SC. ZOOLOGY II SEMESTER**  
**OPEN ELECTIVE 2: DROSOPHILA GENETICS**

**48 Hrs**

**UNIT I *Drosophila* as model:** 12 hrs

a) Mendelian inheritance in *Drosophila* b) sex linked inheritance c) Interaction of genes in *Drosophila* d) polytene chromosome e) concept of gene-experiments on lozenge locus in *Drosophila*

**UNIT II Cytogenetics of *Drosophila*:** 12 hrs

a) Chromosomal aberrations b) Cytogenetic implications of Deletions, Duplications, Inversions, Translocations, Centric fusion and Centric fission c) Practical applications of rearrangements in *Drosophila*.

**UNIT III Developmental genetics of *Drosophila*:** 12 hrs.

a) Early development b) pattern formation: Antero posterior, Terminal group genes and Dorso-Ventral axis formation, Homeotic genes and body plan, c) Pattern formation in imaginal discs.

**UNIT IV Mutations:** 12

hrs. Induction and detection of mutations in *Drosophila* b) Chromosomal and Molecular basis of sex determination in *Drosophila* d) Molecular basis of dosage compensation in *Drosophila*

**TUTORIAL: DROSOPHILA GENETICS**

Tutorials to include brain storming sessions, discussions and seminar presentations 2x16=32

**REFERENCES:**

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5. Strickberger M. W. (2012): Genetics. Mac Millan Publishing Co. New York
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**M.SC. ZOOLOGY III SEMESTER**  
**HARD CORE 10: ETHOLOGY AND EVOLUTIONARY BIOLOGY** **64hrs**

**PART – A: ETHOLOGY**

**UNIT – I: Study of animal behavior-** **16hrs**

- a. Descriptive versus experimental approaches.
- b. Reflexes and complex behaviour- Latency, after discharge, summation, warm up, fatigue inhibition and feedback control;
- c. Instinctive Behaviour - Fixed action pattern, Types of sign stimuli and releasers as triggers ;Genetic basis of instinctive behavior ;
- d. Learning- Classical conditioning experiment, latent and insight learning. Social learning; Altruism;
- e. Anti predator behaviour – avoiding detection through colour and Markings (Mullerian mimicry), Warning coloration. Batesian mimicry;
- f. Biological communication: Forms of signals, vision, audition and chemicals; Role of pheromone-Insects social organization; pheromone effects in mammals- Lee Boot, Whitten, Bruce, Collidge and Castro-Vandenberg effect/s

**UNIT-II: Approaches for studying the genetics of behavior** **16hrs**

- a. Low tech' approaches
- b. Quantitative genetic approaches
- c. Candidate gene approaches
- d. Genomic
- e. Quantitative trait locus mapping
- f. Microarray approaches
- g. Other whole-genome approaches
- h. Behavioural Genetics: a) Inheritance of behavioral traits b) Nest cleaning behavior in honey bees d) Circadian rhythm in *Drosophila* c) Genetic dissection of behavior using mutations in *Drosophila*

**PART B : EVOLUTIONARY BIOLOGY**

**UNIT III** **16 Hrs**

- a. **Theories of Evolution:** Overview of Lamarckism, Darwinism; Development of Neo-Darwinism-Mendelian Population; Gene pool, Allele and Genotype frequencies; Hardy-Weinberg genetic equilibrium.
- b. **Forces of Evolution that affect the allelic frequencies:** Mutation, Migration, Selection- Stabilizing selection, Directional selection, Disruptive selection, Balancing selection, Frequency dependent selection, Density dependent selection, Group and kin selection ;Selection coefficient; Selective value; Genetic drift; Nonrandom mating.
- c. **Human evolution:** Hominid evolution: Anatomical, Geographical, Cultural; Molecular phylogenetics of *Homo sapiens*; Phyletic gradualism and punctuated equilibrium

- a. Isolating mechanisms and speciation:** Concepts of species; Isolating mechanisms - Geographic, Reproductive isolation - Premating isolation- Climatic, Seasonal, Habitat, temporal, Ethological; Post mating isolation- gametic mortality, zygotic mortality, Hybrid inviability, Hybrid sterility, Hybrid breakdown ; Origin of reproduction isolation- Muller's view, Dobzhansky's view; Models of speciation - sympatric, allopatric, stasipatric; speciation by hybridization
- b. Molecular Evolution:** Molecular clock - Conversion of genetic distance into divergence time, Neutral theory of molecular evolution , Emergence of Non-Darwinism, Kinds of molecular data used in phylogenetic analysis, Phylogenetic considerations based on nucleotide and amino acid data.

## REFERENCES

### Ethology

1. Alcock , J. ( 2001): Animal Behaviour, an Evolutionary Approach. Sinauer associates, INC. Sunderland, Massachusetts. USA
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6. Manning, A. and Dawkins M.S. (1997): Introduction to Animal Behaviour, 5<sup>th</sup> edition, Cambridge University Press. UK.
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8. Stumpter, T. J. D. (2010): Collective Animal Behaviour Princeton University Press. Oxford

### Evolutionary Biology

1. Dobzhansky, Th., F. J. Ayala, G. L. Stebbins and J. M. Balentine, (1976): Evolution. Surjeet Publication, Delhi.
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5. Stearns, S. C. and Hoekstra, R. F.(2000): Evolution: An Introduction.Oxford University Press. Oxford.
6. Strickberger, M. W. (1990): Evolution. Jones and Bartlett Publishers. Boston.
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8. Futuyma, D. J. (2013): Evolution. Macmillan education



**M.SC. ZOOLOGY III SEMESTER  
HARD CORE 11: APPLIED ZOOLOGY**

**48 Hrs**

**UNIT I Beneficial Insects**

**12 Hrs**

- a. Meaning and scope of Applied Zoology.
- b. Apiculture: Honeybee species, Bee forage, Pollen calendar, Beekeeping, bee hive products, honeybee diseases and management.
- c. Lac culture: Lac insects, host plants, Lac culture and by products.
- d. Sericulture: Silkworm races, Life cycle of *Bombyx mori*, silkworm rearing, Grainage activity, Seed area, Silkworm diseases and their control. Pests and predators of silkworms.
- e. Insects as tools in Forensic Science.

**UNIT II Harmful insects**

**12 Hrs**

- a. Plant insect interactions: Origin of insect pests, pest control and IPM.
- b. Pests of cereals and pulses: Rice, Wheat, Jowar and Zeyamays, Green gram, Bengal gram (one pest from each category).
- c. Pests of millets and commercial crops: Finger millet, Pearl millet, cotton, coffee, tea (one pest from each category).
- d. Venomous insects and chemical composition of venom and its applications

**UNIT III Animal Farming**

**12 Hrs**

- a. Poultry: Poultry breeds, hatcheries, rearing, poultry diseases and their management and poultry by products.
- b. Dairy: Dairy breeds, dairy farming, Dairy management and by products of dairy.
- c. Laboratory animal science: General principle of breeding and maintenance of small laboratory animals – Rat, Mouse. CPCSEA Guide lines.
- d. Piggery: Pig species, rearing and bi products.

**UNIT IV Fisheries**

**12 Hrs**

- a. Fisheries resources of India: coastal, deep sea and inland fisheries (3 hrs).
- b. Fresh water and marine aquaculture; culturable organisms: prawn, pearl and oyster culture. (4 hrs)
- c. Intensive freshwater fish culture: carps & cat fishes, integrated fish farming, composite and polyculture fish farming, fish by products. (4 hrs)
- d. Ornamental fish culture and sea weeds. (1 hrs)

## PRACTICAL: APPLIED ZOOLOGY

16X2=32 Hrs

### Apiculture:

1. Study of honeybee species and honeybee colony members (queen, drone & worker honeybee). 2x1  
Mounting of mouth parts, sting apparatus and appendages from moribund honeybee worker. 2x1  
Analysis of honey quality: Physical and biochemical parameters. 2x1

### Sericulture:

2. Silkworm egg (DFL), silkworm larva, pupa and adult moths, bivoltine and multivoltine cocoons, non-mulberry silkworm cocoons, silkworm pests-Uzi fly and Dermested beetles. 2x2
3. Insect pests: Rice, wheat, Jowar, vegetables, coffee, cotton, millet and Pulses pests. 2x2
4. Venomous insects and insects of Forensic Science importance. 2x2

### Poultry & Dairy:

5. Study of Quality parameters of Egg and milk. 2x2

### Aquaculture:

6. Commercially important inland and marine fishes, prawn and ornamental Fishes. 2x1  
Fixing and presentation of dead insects by Plastination Technique. 2x2
7. **Field Visits:** Fish Farm, Sericulture, Apiculture and Lac culture Farms, Dairy and Poultry Farms and Visit to Animal House. 2x2

### REFERENCES

1. Anonymous. (2000). Mriculture. FAO Manual, Vol. 1. WHO, Rome, Italy.
2. Anonymous. (2000). Silkworm rearing. FAO Mannual, Vol. 2. WHO, Rome, Italy.
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10. Shukla, G.S. and V.B.. Upadhyay. (2007). Economic Zoology. Rastogi Publications, Meerut, India.

## M.SC. ZOOLOGY III SEMESTER

### HARD CORE 12: ADVANCED DEVELOPMENTAL BIOLOGY

48 Hrs

#### UNIT I

16 Hrs

- a. Introduction:** i) Issues in developmental Biology developmental process: Autonomous specification - (Yellow Cytoplasm, gcl ), Conditional specification induction) ii) Mechanisms regulating morphogenetic determinants - Cell Cell Interaction (Lens induction)
- b. Pattern Formation:** Laying down the primary body axis- i) *Drosophila* (Anterior/posterior, terminal group genes, Dorso/ventral axis) ii) Amphibians (Dorso/ventral) iii) Left –right axis in mammals. iv) Segmentation genes: Gap genes, Pairule genes, Segment polarity genes in *Drosophila*. v) Homeotic Selector genes in flies, mammals (Hox code).

#### Unit II

16 Hrs

- a. Morphogenesis: a)Gastrulation:** i) Morphogenetic movements and selective affinities of cells (cadherins and differential adhesion) ii) Molecular regulators of mesodermal migration (fibronectin, lamin, integrin)
- b. Neurogenesis** i). Neuronal specification -Notch signaling- a skin/nerve regulatory switch in flies. ii). Axonal path finding: Attractants and repulsive signals – (long range and short range- Lamin, Netrins, Semaphorins, Neurotrophins), Target selection and forming the synapse. Example:Retinal axon pathfinding
- c. Mesoderm-vertebrate heart development** (heart field specification, migration, differentiation, looping and chamber formation)

#### UNIT III

16 Hrs

- a. Limb development:** i) limb bud formation & specification (FGF, Hox, Tbx, genes, retinoic acid) ii) Digit formation- A/P axis specification and ZPA, Cell death in digit formation.
- b. Metamorphosis and Regeneration:** i) Molecular mechanism of ecdysone action-cellular choice between apoptosis and differentiation. ii) Molecular responses to thyroid hormone during metamorphosis (Amphibians). iii) Blastema formation and differentiation during regeneration. ( Morphollaxis in Hydra and Epimorphosis in Salamander)
- c. Developmental mechanisms of evolutionary changes** i) Genetic mechanisms- Heterotopy (loss of limbs in snakes, Turtle shell) , Heterochrony (Dolphin flippers) , Heterometry (Darwin's Finches), Heterotypy (Why insects have six legs) ii) Homologous genetic pathways of development –Deep homology

## PRACTICALS: ADVANCED DEVELOPMENTAL BIOLOGY

8X4=32

1. Live observation of *Drosophila* embryogenesis. 1X4
2. Dissection and mounting of Imaginal discs of *Drosophila*. 1X4
3. Study of gene expression during development with lac-Z reporter gene in Embryos.  
(Demonstration) 1X4
4. Reporter gene Lac-Z expression in imaginal discs. 2X4
5. Study of homeotic and maternal effect mutations. 1X4
6. Observation of GFP tagged reporter expression in embryos, imaginal disc and others. 1X4
7. Chick embryo mounting and study 1X4

## REFERENCES

1. Gilbert, S. F. (2003): Developmental Biology. John Wiley Publishing.
2. Gilbert, S.F. Barresi, M.J.F. (2016): Developmental Biology Wolpert, L, Beddington R, Jessel T, Lawrence P, Meyerowitz E, Smith J, (2002): Principles of Development, Oxford University Press.
3. Rao, V.(1994). Developmental Biology: A Modern Synthesis. Oxford and IBH New Delhi.
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**M.SC. ZOOLOGY III SEMESTER**  
**HARD CORE 13: GENERAL AND MOLECULAR ENDOCRINOLOGY 48 Hrs**

**UNIT I** **12 Hrs**

**a. Hormones :**

i) History, ii) Endocrine, Paracrine and autocrine secretions, Local hormones, Neuroendocrine secretions and Neurotransmitters iii) An overview of Mammalian endocrine system, iv) An overview of general classes of chemical messengers-Peptide, Amino acid derivatives and Steroid hormones; v) Neurotransmitters-Neuropeptides, vi) Growth stimulating factors, Chaperones, Eicosanoids and Pheromones. (3 hrs)

**b. Hormones and Homeostasis :**

i) Glucose, Calcium and Sodium Homeostasis, ii) Neuro-endocrine integration: milk ejection reflex and water balance. (4 hrs)

**c. Endocrine Methodologies :**

i) Histological-Cytological, ii) Surgical and Hormone replacement Therapy, iii) Bioassay, iv) RIA, v) ELISA, vi) Recombinant DNA techniques, vii) Gene knockout animal models. (5 hrs)

**UNIT II** **12 Hrs**

**a. Genetic control of hormone synthesis:**

i) Structure and expression of protein hormone encoding gene- Posttranslational modification, molecular aspects of peptide hormone secretion and delivery, ii) Transport and peripheral activation of hormones. (5 hrs)

**b. Mechanism of hormone action :**

i) Membrane bound, cytoplasmic and nuclear hormone receptors, ii) Regulation of receptor number, iii) Non-genomic mechanism of hormone action, Signal transduction: secondary messengers - cyclic AMP, prostaglandins, DAG and calmodulin, iv) Genomic mechanism of hormone action-Steroid and thyroid hormones - regulation of gene expression v) Termination of hormone action and metabolism of hormones. (5 hrs)

**c. Invertebrate Endocrinology :** Structure, functions and molecular actions of insect and crustacean hormones with special reference to reproduction. (2 hrs)

**UNIT III** **12 Hrs**

**a. Hypothalamo-Hypophyseal system :**

i) Endocrine Hypothalamus : Structure, Chemical nature and control of secretion of hypothalamic hormones-TRH, GHRH, GnRH, CRH, Somatostatin and dopamine, Control of release of these hormones and their action on target cells, ii) Pituitary- Location, Development, structure and functional cell types, Hypothalamo-hypophysial portal system, Pituitary hormone and their physiological actions with emphasis on molecular mechanisms-GH and Prolactin, FSH, LH and FSH (Glycoprotein Hormones), Pro-opiomelanocortin and Neurohypophysial Hormones, iii) Control of Hypophysial Hormones, secretion and Feed back regulation, iv) Pituitary patho-physiology : Hyperprolactinaemia, Pituitary dwarfism, Gigantism and Acromegaly. (7 hrs)

- b. Pineal gland :** Morphology and physiological actions of melatonin (1 hr)
- c. Endocrine Pancreas :**
  - i). Structure and cell types of Islets of Langerhans, ii). Secretion and metabolism of Insulin, Glucagon and other pancreatic hormones, iii). Cellular and molecular actions of Insulin and Glucagon, iv). Insulin and Non Insulin Dependent Diabetes Mellitus, v). Islet cell tumor (4 hrs)

#### **Unit IV.**

**12hrs**

- a. Thyroid and Parathyroid Glands:**
  - i). Position and Morphology, ii). Bio-chemistry of synthesis, secretion and metabolism of thyroid hormones and Parathormone, iii). Actions with emphasis on molecular mechanisms, iv). Patho-physiology-Goiter, Grave's disease and Cretinism. (5 hrs)
- b. Adrenal Gland.**
  - i). Anatomy, embryology and histology, ii). Control of synthesis, secretion and physiological roles of cortical hormones with emphasis on molecular actions, iii). Adrenal chromaffin tissue : Synthesis, and actions of catecholamines, iv). Addison's disease and Cushing's syndrome. (5 hrs)
- c. Gastro-Intestinal Hormones :** Endocrine cells, Gastrin, CCK and Secretin (2 hrs)

#### **REFERENCES:**

1. Bolander ,Jr F.F. (2004) Molecular Endocrinology Third Edition. Academic press. SanDiego.
2. Goodman, H.M (2003). Basic Medical Endocrinology. Third Edition. Academic press. SanDiego.
3. Melmed, S., Polonsky,K., Larsen , P.L., Kronenberg, H. M. (2016 ) : Oxford Textbook of Endocrinology and Diabetes.
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**M.SC. ZOOLOGY III SEMESTER  
SOFT CORE 5: GENETIC ENGINEERING**

**48 Hrs**

**UNIT I**

**16 Hrs**

**Principles of Genetic Engineering:** Nucleic acids isolation (principles of isolation, purification and quantification); DNA modifying enzymes -Restriction and modification enzymes, Other nucleases, Polymerase, Ligase, Kinases and Phosphatases; Cloning vectors -Plasmids, Phages, Cosmids, Artificial chromosomes and Expression vectors; Cloning hosts -*E. coli*, *Saccharomyces*, Plant and animals cells.; Gene transfer -Physical and vector mediated methods and cloning methods (Directional cloning and TA cloning methods) ; Construction of libraries -Genomic library, cDNA library and expression libraries

**UNIT II**

**16Hrs**

**PCR:** Principle, Methodology, Types - RT-PCR, AFLP, RFLP, inverse PCR and Real time PCR and their applications. DNA finger printing

**DNA sequencing:** DNA sequencing methods and their applications- Maxam and Gilbert's method, Sanger's method, Automated sequencing technique and Capillary gel electrophoresis, Next Generation Sequencing (NGS) methods

**UNIT III**

**16 Hrs.**

**DNA Engineering techniques:** Gel electrophoresis of nucleic acids and proteins (agarose, polyacrylamide) ; Blotting of macromolecules and hybridization- Probe Selection and labeling, principles of hybridization; gene screening-colony, plaque, dot, Southern & Northern blot screening, Antibody screening; Oligonucleotide synthesis ; Promoter characterization, Site directed mutagenesis; Generation of transgenic animals (*Drosophila* and Mouse)

- |   |     |
|---|-----|
| 1. Demonstration of instruments and calculation for making of stock and working solutions . | 1X4 |
| 2. Isolation of DNA by phenol chloroform method .   | 2X4 |
| 3. Analysis of DNA by agarose gel electrophoresis .   | 1X4 |
| 4. <i>In vitro</i> amplication of DNA by PCR.   | 1X4 |
| 5. Restriction digestion of DNA and analysis.   | 1X4 |
| 6. Ligation of DNA fragments and analysis.  | 1X4 |
| 7. Immunodiffusion.   | 1X4 |

**REFERENCES**

1. Brown, T. A. (1995): Gene Cloning: An introduction. Chapman and Hall, London
2. Brown, T. A. (2015): Gene Cloning: An introduction. 7th edition. Chapman and Hall, London
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5. Primrose, S. B., and R. M. Twyman . (2006): Principles of gene manipulation and Genomics, Blackwell Publishing MA. USA.



**M.SC. ZOOLOGY III SEMESTER  
SOFT CORE 6: ADAPTATION BIOLOGY**

**48Hrs**

**UNIT-I Introduction**

**12 hrs**

Definition, Types of adaptations-Physical and behavioral, Environmental conditions of aquatic, terrestrial, xeric and aerial habitats. Nature of interaction with the environment-Tolerance, resistance, acclimation and acclimatization, Physiological Effects of temperature change in animals-Q 10 effect; Lethal temperature, causes of thermal death (high and low temperature).Light conditions - eclosion in insects.

**UNIT II : Aquatic life:**

**12 hrs**

Adaptations of marine, intertidal, estuarine and fresh water animals (Lentic and lotic) with emphasis on morphological and physiological adaptations.

**UNIT III: Terrestrial and aerial life:**

**12 hrs**

Adaptations for life in forest, grass land and desert  
Flight adaptations-morphological and physiological in insects and birds

**UNIT IV:**

**12 hrs**

**A) Life in extreme environments:**

Adaptations for life in Deep -sea and caves; Effects of depleted oxygen availability; adaptations for deep-sea diving and high altitude conditions.

**B) Biological rhythms**

Rhythms as adaptive feature, Types of rhythms, Circadian rhythms – Examples in man, jet lag, health Impacts of disruption in sleep-wake rhythm, Entrainment, Phase shift, Phase response curves (PRC) and phase transition curves (PTC); Clock genes, Clock medicine.

**TUTORIALS: ADAPTATION BIOLOGY**

**16x2=32**

Tutorials to include brain storming sessions, discussions and seminar presentations

## REFERENCES

1. Dejours, P. (1985): Principles of Comparative Respiratory Physiology, Academic Press NY.
2. Hadley, N. F. (1975): Environmental physiology of Desert organisms, Dowden, Hutchinson & Ross, University of California.
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8. Prosser, C.L.(1986) Adaptation Biology: Molecular to organisms. John Wiley and Sons.
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12. Weibel, E.R., Taylor C.R., Bolis L. (1998) Principles of Animal Design, Cambridge – University Press.

**M.SC. ZOOLOGY III SEMESTER  
OPEN ELECTIVE 3: REPRODUCTIVE HEALTH**

**48Hrs**

**UNIT – I**

12 Hrs

- a. Male and Female reproductive system, Structure and functions of Primary and accessory reproductive organs, formation of spermatozoa and egg, .
- b. Onset of puberty and its Hormonal control in male and female, Menstrual cycle and its hormonal control

**UNIT – II**

12 Hrs

- a. Events of fertilization
- b. Process and hormonal control of pregnancy, parturition and lactation

**UNIT – III**

12 Hrs

- a. Fertility control: Need, Male and female temporary and permanent contraceptives.
- b. Assisted Reproduction: Causes of infertility in male and female, Sperm bank, Procedure of test tube baby : collection of ova, IVF, surrogate mother, GIFT, ZIFT, ICSI,

**UNIT – IV**

12 Hrs

- a. Sexually transmitted diseases (STD): Meaning, Psychological aspects of STD.
- b. Incidence, causes, transmission, symptoms, diagnosis and treatment of Gonorrhoea, Syphilis, Herpes, Chlamydia, genital warts, AIDS, Vaginitis,

**TUTORIAL: REPRODUCTIVE HEALTH**

2x16=32 Hrs

Tutorials to include brain storming sessions, discussions and seminar presentations

**REFERENCES**

1. Austin, C. R and R. V. Short (eds) (1972) :Reproduction in mammals. (1) Germ cells and Fertilization, (2) Embryonic and Foetal development, (3) Hormones in Reproduction, (4) Reproduction patterns (5) Artificial control of reproduction, Cambridge University press, London.
2. Jones, R. E (1991) :Human Reproductive Biology , Academic press N.Y
3. Paul Wassar man and Jimmy D. Neill (2005) :Knobil and Neill's physiology of reproduction, volume 1and 2, Raven press, N. Y
4. Sasidhara R (2006) :Animal biotechnology recent concepts and development, MJ Publishers, Chennai.
5. Sawant K C (2001) Human Physiology , Dominant Publishers and Distributors, New Delhi

**M.SC. ZOOLOGY IV SEMESTER  
HARD CORE 14: ENVIRONMENTAL BIOLOGY**

**48 Hrs**

**UNIT - I Ecosystem:**

**12 Hrs**

- a. Historical account, scope, basic concepts, components of environment and approaches to the study of Environmental Biology.
- b. Concept of habitat and ecological niche; ecotone and edge effect; food chains, Food-webs and their structure; ecological pyramids in aquatic, terrestrial and parasitic environments.
- c. Brief description of biogeochemical (N,C,P) cycles.
- d. Ecological productivity and its measurement.

**UNIT - II Population Ecology**

**12 Hrs**

- a. An overview of important population attributes – density, natality, growth rates - growth forms and concept of carrying capacity.
- b. Mortality - life tables and survivorship curves.,
- c. Sex ratio, age distribution, dispersal and dispersion, aggregation and Allee's principle, population fluctuation & cyclic oscillations and Population interactions.
- d. Ecological model - nature of ecological models; goals of model building; basic tools in model building. Approaches to development of models with examples (Energy flow models).

**UNIT - III Environmental pollution:**

**12 Hrs**

- a. Definition, causes, effects and control measures and monitoring of – Air Pollution - green house effect, global warming, Ozone layer depletion, photochemical smog and acid rain; Water Pollution with reference to major Indian rivers and marine pollution; Soil, Noise, Thermal, and Nuclear Pollution - with special reference to present scenario in India.
- b. Pollutants and their impact on flora, fauna and humans; Solids and Biomedical wastes - causes, effects and control measures and their management.
- c. Microbial Ecology: Indicator Microorganisms. Role of microorganisms in biodegrading and bioremediation of organic and metal pollution. Biodegradation, biotransformation, biomagnification and bioaccumulation of toxicants.
- d. Role of Central and State Pollution Control Boards.

- a. Conservation and management of natural resources- types, need, strategies of conservation. Significance of non - conventional energy resources: solar, wind, geo-thermal, tidal, nuclear and bio –energy.
- b. Natural hazards - Earthquakes, Cyclones, Volcanoes Tsunami and their causes;
- c. Environment and Social issues - Resettlement and rehabilitation of people, Wasteland reclamation and Environmental ethics.
- d. Environmental Protection Act -1986 and related Acts.

**REFERENCES:**

1. Chapman R. L. & Reiss, M. J. (2000). Ecology – Principles & Application. Cambridge Low Price Edition.
2. Chapman, J.L and Reiss, M.J. (1999): Ecology: Principles and Applications. Cambridge University Press
3. Collin R, Townsend, Harper J L, and Michael Begon (2000): Essentials of ecology. Blackwell Sci. Comp.
4. Jorgensen,S.E. Fundamentals of ecological modeling. Elsevier, New York.
5. Kormondy, E. J. (2007): Concepts of Ecology. 4 th ed. Indian reprint, Pearson Education.
6. Krebs, C J. ( 1994) Ecology , Harper and Collins
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9. Odum, E. P. (1971). Fundamentals of Ecology. W. O. Saunders company, Philadelphia.
10. Odum, E. P. (1983). Basic Ecology. CBS College Publishing.
11. Odum, E.P. 1(1983.) :Basic Ecology, Holt Saunders, Japan.
12. Odum. E.P. (1996 ).:Fundamentals of Ecology. Nataraj Publishers, Dehra Dun.
13. Paul Colinvaux, (1986): Ecology. John Wiley and Sons, N.Y.
14. Peter Stilling, Ecology: Theory and applications. 2nd ed. Prentice Hall, International Edn.
15. Sharma P.D (2011): Ecology and Environment. Rastogi Publication, Meerut.

**PRACTICAL: ENVIRONMENTAL BIOLOGY**

**2X 16 = 32Hrs**

1. Field visit to sewage pond, natural lake / river: Collection of water samples and study of physico-chemical parameters such as colour, pH, temperature, conductivity, total solids and turbidity. 2X1
2. Estimation of Carbon di-Oxide and dissolved Oxygen in three natural (sewage, pond and Tap) water samples. 2X2
3. To study the relationship between Dissolved oxygen and free carbon dioxide, if any, in three natural (sewage, pond and Tap) water samples. 2X1
4. Determination of COD and BOD in three natural (sewage, pond and Tap) water samples. . 2X2
5. To study the relationship between BOD and COD, if any, in three natural (sewage, pond and Tap) water samples. . 2X1
6. Estimation of primary productivity of water bodies . 2X1
7. Population ecology- Population growth in Paramecium/ Drosophila 2X1
8. Estimation of Phosphate concentration in three natural (sewage, pond and Tap) water samples. 2X1
9. Estimation of Nitrate concentration in three natural (sewage, pond and Tap) water samples. 2X1
10. Determination of population density in a natural/ hypothetical community by quadrat method and calculation of Ecological indices for the same community 2X2
11. .Visit to RNHM, Mysore, to study models of freshwater, marine, estuarine and terrestrial habitats. 2X1
12. Survey of Animal Population - to visit different habitats/areas in and around Mysore and collect data on some population attributes; application of Bio-statistical tests to the collected data and its interpretation.
13. C1 and C2 assessment 2X2

**REFERENCES**

1. APHA, 1992: Standard methods for examination of water and waste water, 18th Ed.
2. Fahey, T.J. and Knapp, A.K., (2007), Principles and Standards for Measuring Primary Production, Oxford University Press, UK
3. Zuur, A. F., Ieno, E. N. & Smith, G. M. (2007). Analysing Ecological data. Springer Science & Business Media.
4. Trivedi,R.K. and Goel, P.K. (1986): Chemical and Biological methods of water pollution studies. Environmental Publications,Karad
5. Trivedi, P.R.and Gurdeepraj, K. 1992. Environmental Biology. Akashdeep Publishing House New Delhi

**M.SC. ZOOLOGY IV SEMESTER  
HARD CORE 15: ADVANCED CELL BIOLOGY**

**64 Hrs**

**UNIT I Eukaryotic cell cycle & its regulation**

**16 Hrs**

- a. Phases of cell cycle
- b. Regulation: (i) Cell cycle check points (ii) cell intrinsic core regulators of checkpoints- Cyclins and Cdks, CAKs, CKIs, MPF, APC. and regulation at check points (iii) Cell intrinsic mediators of regulation- activators (myc, Ras), inhibitors (Rb, DNA damage P53 dependent and independent inhibition) (iv) Extracellular signals – growth factors (mitogens) (v) Specific regulators at meiosis, regulation of oocyte meiosis.

**UNIT II Cell death:**

**8Hrs**

- a. **Programmed:** (i) Programmed apoptosis v/s necrosis (ii) Discovery of cell death genes in *C.elegans* & homologous pathway in mammals (iii) Caspases – action, inhibition by survival signals (Trophic factors, neurotrophins) and activation by death signals (TNF, Perforin/granzyme pathway, Mitochondrial permeability).
- b. **Alternative Cell Death Mechanisms:** Autophagic, Necroptosis and their significance

**UNIT III Cell signaling:**

**8Hrs**

- a. Endocrine, synaptic, autocrine and Nitric Oxide signaling
- b. Cell Surface receptors: (i) G-protein linked-structure, mechanism, Cyclic AMP mediated (ii) Enzyme linked -Receptor tyrosine kinases (iii) signaling through regulated proteolysis - Wnt- $\beta$  catenin pathway, calcium signaling (iv) Synaptic signaling - Signaling at neuromuscular junction (transmitter gated ion channels, spatial and temporal summation).

**UNIT IV**

**16 Hrs**

- a. **Biology of Neoplasm:** (i) Types of tumors (Benign and Malignant), (ii) Development of cancer, metastasis and properties of cancer cells (iii) transformation of cells in culture, (iv) causes of cancer- Carcinogens (Physical, Chemical and Biological agents).
- b. **Genetics of cancer:** (i) Chromosomes and cancer (Philadelphia, Burkitts lymphoma) (ii) Oncogenes: mechanism of transformation of protooncogenes (iii) RNA tumor virus (Hepatitis) and DNA Tumor virus (Papilloma virus), Retroviral oncogenes, proto-oncogenes, (iv) Tumor suppressor genes: (Rb, BRCA) (v) Cancer as a multistep process, (vi) Cancer therapy: early detection and prevention, molecular diagnosis, treatment, cancer cell lines.

- a. Immunology:** (i) Historical account (ii) General properties of immune responses – Innate immunity and its mechanisms – cellular and molecular basis of inflammation and its importance (iii) adaptive immunity - active, passive and adoptive types (iv) Humoral and cell mediated immunity (v) Cells of the immune system: Hematopoiesis, functions of NK cells, Dendritic cells, Macrophages, B Lymphocytes, T Lymphocytes (vi) Antigens and antigenicity (Epitopes, Haptene) (vii) Immunoglobulins: Classes of immunoglobulins, structure of IgG (viii) Genetic basis of immunoglobulin diversity (ix) MHC molecules: Types, structure (x) Cytokines (xi) Antigen recognition by cytosolic pathway, endocytic pathway
- b. Clinical immunology:** (i) Vaccines – principles of vaccination, Recombinant vaccines, DNA vaccines (ii) Principles of monoclonal antibody production and its applications (iii) Deficiencies in the immune system – AIDS, autoimmune diseases, Hypersensitivity.

**REFERENCES:**

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter (2008): Molecular Biology of the cell. V Ed. Garland Science, New York.
2. Alberts, B, Johnson, J Lewis, M. Raff, K Roberts and P. Watter. (2014): Molecular Biology of the cell. 6th edition. Garland Science, New York.
3. Lodish, H., A. Berk, C.A Kaiser, M.P. Scott, A Bretscher, H. Ploegh, P. Matsudaira. (2016): 8<sup>th</sup> Edition, Molecular Cell Biology. W. H. Freeman and Co., N. Y.
4. Brachet, J. (1985) Molecular Cytology, Academic Press, N. Y.
5. Furukawa, R., and M. Fechheimer. (1997): The structure, function and assembly of actin filament bundles. *Int. Rev. Cytol.* 175: 29-90.
6. Pollard, T. D. and W. C. Earnshaw.( 2002): Cell Biology. Saunders
7. Wolfe, A. (1995): Chromatin: Structure and function. Academic Press, N. Y.



**M.SC. ZOOLOGY IV SEMESTER  
SOFT CORE 7: MAJOR PROJECT**

**M.SC. ZOOLOGY IV SEMESTER  
SOFT CORE 8: RESEARCH METHODOLOGY 48 Hrs**

**UNIT I. Introduction to Research; 12 Hrs**

- a. Purpose and importance of scientific research
- b. Sampling Techniques: Random and non-random sampling methods.
- c. Survey methods: Line Transect, Variable Width Line Transect, All out Search Methods,
- d. Planning and designing a research study: Literature survey and critical review; Identifying the gaps, Defining the problem, Statement of objectives, Selection of methods to achieve objectives, Collection, compilation and Presentation of data.

**UNIT II. Animals models in research and Cell culture: 12 Hrs**

- a. Introduction to laboratory animals – Drosophila, rat, mice, guinea pigs, rabbits. Breeding and management of laboratory animals, bioethics. CPCSEA Guide lines, RRR
- b. Introduction to cell lines; *in-vitro* cell culture systems, primary and secondary Culture systems, applications of cell culture.
- c. Cryopreservation: Scope, principles, Methods and applications, cryoprotectants, cryopreservation of tissue, organs and embryos.
- d. Good laboratory practices, Waste disposal, Maintenance of sanitation & hygiene,

**UNIT III. Biostatistics and computer application 12 Hrs**

- a. Arithmetic mean, mode, median, range, variance, standard deviation and standard error, coefficient of variation
- a. Testing of hypothesis: Statement for testing the hypothesis, statistical validation using student's "t" test, 'z' test, chi square test, simple and multiple correlation, regression analysis, ANOVA., Meaning of level of significance.
- b. Computer applications: MS word, EXCEL, Power point, SPSS uses,

**UNIT IV. 12 Hrs**

**Preparation of Research paper, Thesis and Research Project Proposal preparation.**

- a. Significance of disseminating research results, IPR, Patenting,
- b. Research paper: Preparation of research paper, Importance of peer review in paper publication.
- c. Dissertation/thesis: Collection and compilation of data, organizing a thesis, bibliography.
- d. Research Project Proposal: Identifying a problem, reviewing national and international status, objectives, methodology, budget.
- e. Plagiarism,

Tutorials to include brain storming sessions, discussions and seminar presentations

**REFERENCES**

1. Celis, J.E. (1994): Cell Biology – A laboratory hand book. Vol. I, II and III, Academic Press, London.
2. Freshney, R.I. (2005): Culture of animal cells: A manual of basic techniques. V Edn. Alan R. Liss, Inc. New York.
3. Gurumani, N. (2006): Research Methodology : For Biological Sciences, MJP Publishers, New Delhi
4. Gurmani, N. (2004): An Introduction to Biostatics, MJP publishers, Chennai.
5. Hassard, T.H. (199): Understanding Biostatics. Mcsby Year Bok, London.
6. Tembhare, D.B. (2008): Techniques in life sciences, Himalaya publishing house.

**M.SC. ZOOLOGY IV SEMESTER**  
**SOFT CORE 9 48 Hrs MEDICAL AND**  
**ENVIRONMENTAL IMPACT OF DEVELOPMENTAL GENETICS**

**UNIT I**

**12 Hrs**

**Development and Environment:** (a) Developmental symbiosis (Parasitism, Mutualism, mammalian gut microbes) (b) Embryonic diapause (insects and mammals). (c) Phenotypic plasticity (*Bicyclus anynana*): Polyphenism – nutritional (Dung beetle), seasonal (*Araschina levana*), Diet and DNA methylation (folic acid), predator-induced polyphenism (Daphnia), Environment dependent sexual phenotype (sex peptides and reversal in fishes) d) Learning – Adaptive nervous system (neuro physiology of song learning).

**UNIT II 12 Hrs a)Teratogenesis:** (i) Teratogenic agents and their assault on human development- (a)Alcohol, b)Retinoic acid, c) thalidomide d) endocrine disruptors - DES, BPA (Reproductive, Cancer susceptibility), e) DDT, f)Heavy metals g) pathogens h) Transgeneration inheritance of developmental disorders.

b) Cancer as disease of development: Developmental therapies and differentiation therapy.

**UNIT III**

**12 Hrs**

a) **Developmental anomalies:** (a) Anencephaly - Spina bifida (Folic acid) (b) Cyclopia-Shh mutants (c) Blindness-Rx mutants (d) Deafness

b) **Aging:** Concept of aging: Theories of Aging, Organism aging, a) Cellular changes during aging (DNA damages, shortened telomere, mitochondrial mutation, oxidative stress). b) Aging disease (Progeria) c) Genes and Aging (DNA repair enzymes, Telomerase, p53, Insulin growth factor pathways) d) Epigenetic changes during aging

**Unit IV**

**12 Hrs**

**Stem cells:** i) Embryonic stem cells, Multipotent adult stem cells (Neuronal stem cell, Hematopoietic Stem cell) ii) Application of stem cells: a) Stem cell therapy: transgenic stem cells: Regeneration Therapy, Therapeutic cloning. b) IPS cells and its application, hematopoietic stem cells from cord blood (Eg. Fanconi's anemia). c) Treatment of diseases: Neuro-degeneration and muscular dystrophy d) Organoid derivation from stem cells

**TUTORIAL : MEDICAL AND ENVIRONMENTAL IMPACT OF DEVELOPMENTAL  
GENETICS**

**16x2=32**

Tutorials to include brain storming sessions, discussions and seminar presentations

**REFERENCES:**

1. Gilbert, S. F. (2003): Developmental Biology. John Wiley Publishing.
2. Gilbert,S.F. and Barresi, M.J.F. (2016): Developmental Biology
3. Gilbert, S. F. and David. E. (2009) Ecological developmental biology
4. Leonard, P. Guarente, Linda Partridge, Douglas C. Wallace, (Eds)(2008 ) : Molecular Biology of Aging, Cold Spring Harbor press.
7. Robert Lanza and Anthony Atala ( Eds) (2014): Essentials of Stem Cell Biology 2014 (Third Edition)
8. Al-Rubeai, Mohamed, Naciri, Mariam (Eds) (2014) : Stem Cells and Cell Therapy .M Springer press.

**M.SC. ZOOLOGY IV SEMESTER**  
**SOFT CORE 4 : BIODIVERSITY AND WILDLIFE BIOLOGY** **48 Hrs**

**UNIT I. Scope of Biodiversity** **12 Hrs**

- a. Concept of biodiversity, levels of biodiversity: general theories (biotic and abiotic) of biodiversity.
- b. Biodiversity profile of World, India and Karnataka.
- c. Biodiversity depletion: threatened biodiversity, impact of development, effect of pollution, global warming and climate change.
- d. Mega biodiversity centers in the world, biodiversity hot spots in India and Ramsar wetlands.

**UNIT II. Conservation of Biodiversity** **12 Hrs**

- a. Convention on Biological Diversity, Biodiversity Act, 2002, Biodiversity Board.
- b. Bioethics, IPR, Earth summits, Man and biosphere program (MAB).
- c. Biodiversity mapping, methods of assessment, prospecting, bioremediation, Biodiversity index and techniques.
- d. Management of biodiversity hotspots, biodiversity sustainable development and biodiversity heritage sites in Karnataka.

**UNIT III. Scope of Wildlife Biology** **12 Hrs**

- a. Values of wildlife, wildlife categories: endangered, threatened, vulnerable, rare and extinct species, Red data book, green data book.
- b. Causes of wildlife depletion: degradation and destruction of wildlife habitats, exploitation for commercial purposes, deforestation, urbanization and industrialization, hunting, forest fire and agricultural expansion.
- c. Wildlife corridors, human-wildlife conflicts: Elephant, Tiger, Panther.
- d. Wildlife and tribal welfare, tribes in India and role of tribes in wildlife management.

**UNIT IV. Wildlife Conservation** **12 Hrs**

- a. Wildlife legislation: IBWL, Wildlife Protection Act, 1972.
- b. Wildlife conservation strategies: NGO's - BNHS, WWF, IUCN; ZSI, BSI. Protected area network and wildlife projects.
- c. In-situ conservation: Wildlife sanctuaries, national parks and bioreservers and their management. *Ex-situ* conservation: Zoo garden and its management, Zoo Authority of India, captive breeding, artificial insemination, cryopreservation, germplasm banks.
- d. Wildlife census, techniques and survey methods.

## **TUTORIALS : BIODIVERSITY AND WILDLIFE BIOLOGY 16x2=32 hrs**

Tutorials to include brain storming sessions, discussions and seminar presentations

### **REFERENCES**

1. Agrawal, K.C. (2000). Biodiversity. Agrobios (India) Publishers, Jodhpur, India.
2. Anonymous, (2004) The Biological Diversity Act, 2002 and Biological Diversity Rules (2004). National Biodiversity Authority of Indi. New Delhi.
3. Gaston, K.J. and Spicer, J.I. (1998) Biodiversity - An Introduction. Blackwell Science Publishers, UK.
4. Hosetti, B.B. (1997) Concepts in wildlife management. Daya Publishing House, New Delhi.
5. Kannaiyan, S. and gopalam, A. (2007). Biodiversity in India – Issues and concerns. Associated Publishing Co. New Delhi.
6. Kotwal, P.C. and Banerjee, S. (2004). Biodiversity conservation – in managed forests and protected areas. Agrobios (India) Publishers, Jodhpur, India.
7. Nair, S.M. (1992) Endangered animals of India and their conservation. NBT, New Delhi.
8. Negi, S.S. and Bahuguna, V.K. (1983). An Introduction to Wildlife management. Bishen Singh Mahendra Pal Singh Publ. Dehara Dun, India.
9. Saharia, V.B. (1982). Wildlife in India. Natraj Publishers, Dehara Dun, India.
10. Tikade, B.K. (1983). Threatened animals of India. Zoological Survey of India, Calcutta.

## M.SC. ZOOLOGY IV SEMESTER

### OPEN ELECTIVE 4: ECONOMIC ZOOLOGY

48 Hrs

#### Unit 1. Introduction and scope of Economic Zoology:

12 Hrs

- a. Economic importance of Invertebrates; culture and management of important invertebrates – Apiculture, Corals, Lac culture, Mariculture, Prawn culture, Pearl culture, Sericulture and Vermiculture.
- b. Invertebrate products and byproducts.

#### Unit 2. Economic importance of Vertebrates:

12 Hrs

- a. Rearing and management of important vertebrates – Dairy, Fisher culture, Poultry, Piggery, Pigeonery, Rabbit and snakes.
- b. Usefulness of vertebrate products and by products: Animal oriented Medicine, leather, wool, fur industry.

#### Unit 3. Pests, Parasites and Vectors

12 Hrs

- a. Insects as pests – on food and vegetable crops.
- b. Parasitic protozoa, nematodes, helminthes and their human diseases.
- c. Vectors: Mosquitoes, ticks, mites, cockroaches, rat and their human diseases.

#### Unit. 4. Commercial importance of Insects

12 Hrs

- a. Entomophagy: Entomophagic species and their usage in different parts of the world and economics.
- b. Insects as tools in Forensic Science, usefulness of insects in crime detection.
- c. Insect culture, collection, preservation and Bioethics.
- d. Insects as biological controlling agents. Venomous insects and their venom application to treat various ailments and diseases, Apitherapy.

### TUTORIAL: ECONOMIC ZOOLOGY

16x2=32

Tutorials to include brain storming sessions, discussions and seminar presentations

## REFERENCES

1. Anonymous (1989): Geographical distribution of arthropod borne diseases and their principal vectors. WHO, Geneva.
  2. Arumugam, N., Murugan, T., Johnson Rajeswar J. and Ram Prabu, R. (2016): Applied Zoology. Saras Publication, Nagercoil, India.
  3. Eckert, J.E. and Shaw, F.R. (1990). Beekeeping. Macmillan Co. New York, USA.
  4. Fenemore, P.G. and A. Prakash. (1992): Applied Entomology. Wiley Eastern Ltd. New Delhi.
  5. Gillott, C. (1995): Entomology (2<sup>nd</sup> Edn.) Plenum Press, New York & London.
  6. Gullan, P.J. and Cranston. (1994): The Insects: An Outline of Entomology. Chapman and Hall, London, UK.
  7. Hill, D.S. (1994.0: Agricultural Entomology. Timber Press Inc., Portland, Oregon, USA.
  8. Pradhan, S. (1994) Insect pests of crops. National Book Trust India, New Delhi.
  9. Srivastava, K.P. (1988). A Textbook of Applied Entomology, Kalyani Publishers, New Delhi.
- Shukla, G.S. and Upadhyay, V.B. (2007): Economic Zoology. Rastogi Publications, Meerut, India.