

## Syllabus M.Sc. Zoology

Course code	SEMESTER I	Credit
ZOOL 4001	Non-chordates: Structure and Function and Evolutionary Significance	4
ZOOL 4002	Biosystematics and Biostatistics	4
ZOOL 4003	Ecology and Environment	4
ZOOL 4004	Cell and Molecular Biology	4
ZOOL 4005	Laboratory I	2
ZOOL 4006	Laboratory II	2
		<b>20</b>
<b>SEMESTER II</b>		
ZOOL 4007	Chordates: Structure, Function and Evolutionary Significance	4
ZOOL 4008	Biochemistry and Metabolism	4
ZOOL 4009	Animal Physiology	4
ZOOL 4010	Cytogenetics and Genetics	4
ZOOL 4011	Swayam Course	2
ZOOL 4012	Laboratory I	2
ZOOL 4013	Laboratory II	2
		<b>22</b>
<b>SEMESTER III</b>		
ZOOL 4014	Developmental Biology	4
ZOOL 4015	Evolution Biology	4
ZOOL 4016	Immunology	4
ZOOL 4017	Major Electives I*	4
ZOOL 4018	Swayam Course	2
ZOOL 4019	Laboratory I	2
ZOOL 4020	Laboratory II	2
		<b>22</b>
<b>SEMESTER IV</b>		
ZOOL 4021	Animal Behaviour	4
ZOOL 4022	Animal Biotechnology	4
ZOOL 4023	Major Electives II*	4
ZOOL 4024	Dissertation	8

<b>ZOOL 4025</b>	Laboratory I	2
<b>ZOOL 4026</b>	Laboratory II (Major Elective)	2
		<b>24</b>
<b>Total credits</b>		<b>88</b>

**Major Elective I\*: Course code ZOOL 4017**

- Cytogenetics I: Basic and Applied Cytogenetics
- Cancer Biology I: Basics of Cancer Biology
- Wildlife Biology I: Indian Wildlife
- Neurobiology I
- Entomology I
- Molecular Endocrinology I

**Major Elective II\*: Course code ZOOL 4023**

- Cytogenetics II: Human cytogenetics
- Cancer Biology II: Advanced Cancer biology
- Wildlife Biology II: Conservation and Management
- Neurobiology II
- Entomology II
- Molecular Endocrinology II

**Semester I**  
**Core course ZOOL 4001**

**Non-chordates: Structure and Function and Evolutionary Significance**

**UNIT I**

**Organization of Metazoa:**

Origin of Protozoa, Parazoa and Metazoa  
Origin of Radiata and Bilateria  
Origin, Characters and Types of Metamerism  
Origin, evolution and organization of Coelom

**UNIT II**

**Locomotion, Nutrition and Digestion:**

Flagella and Ciliary movement in Protozoa  
Hydrostatic movement in Coelentrata, Annelida and Echinodermata  
Flight mechanism of insects, Locomotion in Mollusca  
Pattern of Feeding and digestion in lower metazoan  
Filter feeding in Polychaeta, Mollusca, and Echinodermata

**UNIT III**

**Respiration, Excretion and Osmoregulation:**

Respiratory organs and Pigments  
Mechanism of Respiration  
Excretory organs and their mechanism  
Osmoregulation

**UNIT IV**

**Nervous and Reproductive system:**

Primitive Nervous system: Coelentarta and Echinodermata  
Advanced Nervous System: Annelida, Arthropoda and Mollusca, Trends in Neural evolution,  
Reproductive system

**UNIT V**

**Minor phyla and larval forms:**

Introduction to minor phyla, characters and significance  
Larval forms and their significance, free living, parasitic, freshwater, and marine

**List of recommended books:**

1. Invertebrates 2<sup>nd</sup> Ed .: Richard C. Brusca, et al.Sinauer Associates, Inc., Publishers

2. Invertebrate Zoology: A Functional Evolutionary Approach, 7th Ed.: Edward E. Ruppert  
Richard S. Fox Robert D. Barnes Cengage Learning
3. Biology of the Invertebrates : Jan Pechenik McGraw Hill Ryerson publication
4. Invertebrate Zoology 3<sup>rd</sup> Ed.: Paul A. Meglitsch, Oxford University Press.
5. Invertebrate Zoology 6<sup>th</sup> Ed.: Barnes, R. D. and Ruppert, E. E., Brooks Cole.
6. Modern Text Book of Zoology: Invertebrates: R. L. Kotpal Rastogi Publications

**Practicals:**

1. Study of Museum specimen and slides from different invertebrate phyla.
2. Preparation of the permanent slide of the material available.
3. Demonstration of digestive, reproductive and nervous system of Cockroach.
4. Mounting of:
  - A. Body setae of *Earthworm*.
  - B. Mouth part of insects.
  - C. Salivary gland of Cockroach.
  - D. Invertebrate larvae.
5. Collection and identification of invertebrates in pond water.
6. Field study report.

**Core course ZOOL 4002**  
**Biosystematics and Biostatistics**

**UNIT I**

**Principles and methods of taxonomy:** Concepts of species and hierarchical taxa, Important criteria used for classification in each taxon, Evolutionary relationships among taxa, biological nomenclature, classical and quantitative methods of taxonomy of animals, microorganisms.

**UNIT II**

**Methods in field biology:** Methods of estimating population density of animals, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.

Molecular basis of conservation of diversity, Cyto-chemo-molecular taxonomy

**Biodiversity Indices:** Shannon-Weininger Index, Dominance Index, Similarity and dissimilarity index, Association index

**UNIT-III**

**Nature and scope of Biostatistics:** Primary and Secondary data, Methods of data representation (Tabulation and Graphics), Frequency distribution, Central tendency, Dispersion, Hypothesis testing (t-test, Chi-square test), R x C Contingency table.

## UNIT-IV

**Bivariate Data:** Central and raw moments up to fourth order, Skewness, Kurtosis and their measures, Analysis of Variance (ANOVA) - One way and Two way, Post hoc test, Correlation, Regression.

## UNIT-V

**Probability:** Concept, Classical and Statistical definition of probability, Additive and Multiplicative theorems of probability, Conditional probability and Baye's theorem, Binomial, Poisson and Normal distributions with their properties and applications.

**Non-parametric statistics:** Mann-Whitney U, Wilcoxon matched-pairs test, Kruskal- Wallis test.

### **List of recommended books:**

1. Principle of Animal Taxonomy: G. G. Simpson, Oxford IBH Publishing Company
2. The Diversity of Life: E. O. Wilson, WW Northem and Company
3. Biodiversity: E. Mayer, Academic Press, London
4. Statistical methods 8<sup>th</sup> Ed: GW Snedecor and WG Cochran, East-west press.
5. Biomtery, 3<sup>rd</sup> Ed.: RR Sokal, and FJ Rohlf, Freeman
6. Biostatistical Analysis, 5<sup>th</sup> Ed.: JH Jarr, Pearson
7. Computational book of statistics, 2<sup>nd</sup> Ed.: J.L Bruning and, B.L. Scot Kintz, Foresman and company.
8. Medical Statistics at a Glance: A Petrie, and C. Sabin, Blackwell Science
9. Statistics, 4<sup>th</sup> Ed.: DH Freedman R Pisani, R Purves, WW Norton and Company

### **Practicals:**

1. Taxonomic identification using keys
2. Preparation of models showing the status of certain taxa or species in a given habitat
3. Calculation of Biodiversity indices for a given habitat (grassland, arid land, and wetland):
  - a. Shannon-Weiner species diversity index
  - b. Shannon evenness index
  - c. Simpson dominance index
  - d. Species richness, species evenness, and Relative abundance, Community evenness
  - e. Berger parker dominance
  - f. Bray-Curtis index of dissimilarity
4. Influence of climatic conditions on taxonomic diversity in a given habitat
5. Data collection, management and analysis
6. Calculation of Central tendency & Dispersion
7. Hypothesis testing (t-test, Chi-square test)
8. R x C Contingency table
9. Bivariate statistics
10. Probability
11. Non-parametric statistics

**Core course ZOOL 4003**  
**Ecology and Environment**

**UNIT I**

**Aim and Scope of Ecology:** Abiotic factors and biotic factors, Concept and Dynamics of ecosystem, Types of Ecosystem (Lentic, Lotic, Estuaries and Marine), Energy flow: Lindeman's rule of trophic dynamics, energy flow models.

**UNIT II**

**Biogeochemical cycles:** Nitrogen, Carbon, Sulphur and Phosphorous cycle, Principles pertaining to limiting factors: Liebig's Law of minimum, Shelford's Law of tolerance, Concept & Law of limiting factors, Factors compensation and ecotypes.

**UNIT III**

**Population ecology:** Population dynamics, Intrinsic rate of natural increase, Population growth form, Population fluctuations and cyclic oscillation, Population density and structures, r- and k- selections and carrying capacity, Concept of niche, niche width and overlap, fundamental and realized niche, resource partitioning character displacement. Biological communities and species interactions, types of interactions between two species, Lotka-Volterra equation for competition and predation, interspecific competition, Ecological succession.

**UNIT IV**

**Environmental pollution:** Cause, effect, and control of Water, Air, Noise, Thermal and Radioactive pollution, Bioaccumulation and Biomagnification, Carbon dioxide fertilization and Global warming.

**UNIT V**

**Global Environmental Issues:** Value, Threats and Conservation of Biodiversity including wildlife, Climate Change, Carbon Footprint, Water Security – conservation of surface and ground water, Project Tiger and Biosphere reserves

**List of recommended books:**

1. Colinviaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
4. Odum, E. P. and Barrett, G. W. (2006). Fundamentals of Ecology, 5th Edition, Cengage Learning India.
5. Shyam, D. and Rosencranz, A. (2001). Environmental Law and Policy in India. Oxford University Press
6. Sharma, P. D. (1990). Ecology and Environment, 13th Edition. Rastogi Publications.

7. Robert Leo Smith Ecology and field biology Harper and Row publisher Ricklefs, R.E.,(2000). Ecology V Edition. Chiron Press

### **Practicals:**

1. Field work to understand ecological concepts.
2. To determine population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
3. To study different types of survivorship curves from hypothetical/real data provided.
4. To analyze soil/pond biota
5. To determine dissolved oxygen and pH of different water samples,
6. To visit National Park/Biodiversity Park/Wild life sanctuary and prepare report.

## **Core course ZOOL 4004** **Cell and Molecular Biology**

### **UNIT I**

**Internal organization of the cell:** Plasma membrane structure and functions (protein diffusion, osmosis, ion channels, active transport, membrane pumps). Intracellular organelles including nucleus, mitochondria, golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes. Protein sorting & targeting; Structure & function of cytoskeleton and its role in motility.

### **UNIT II**

**Organization of gene and Chromosomes:** Eukaryotic and prokaryotic organization of genes and chromosomes and genomes, Operon concept, Structure of chromatin & chromosomes, Unique & repetitive DNA, heterochromatin & euchromatin, Interrupted genes, Transposons.

### **UNIT III**

**DNA Replication:** Prokaryotic and Eukaryotic DNA replication, mechanisms of DNA replication, fidelity of replication, extra chromosomal replicons. DNA damage and repair mechanisms.

**Gene expression and its regulation:** Transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation.

**Protein synthesis and processing:** Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post-translational modification of proteins.

### **UNIT IV**

**Cell division and cell cycle:** Mitosis and meiosis, steps in cell cycle, regulation and control of cell cycle. Maturation promoting factor (MPF), Cyclins and cyclin dependent kinases, Cancer

cell cycle and apoptosis, cancer and the cell cycle , oncogenes, tumor suppressor genes, interaction of cancer cells with normal cells, apoptosis.

## **UNIT V**

**Cellular communication:** General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins.

**Cell signaling:** Hormones and their receptors, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, tyrosine kinases; MAP kinase cascade, STAT.

### **List of recommended books:**

1. Molecular biology of the Cell –Bruce Albert Pub. By Garland Pub. Inc. New York & London.
2. Molecular Cell biology – Lodish Berk, Matsudaira, Kaiser, Krleger (2004) pub. By W.,H. Freeman & Company, New York.
3. Molecular cell biology – Gerald carp (2005) pu. By John Wiley & Sons
4. Alberts B, Johnson A, Lewis J, et al. Molecular Biology of the Cell, Taylor & Francis Group, New York, USA. 2. Lodish H, Berk A, Lawrence S, et al., Molecular Cell Biology, Freeman WH & Co. New York.

### **Practicals:**

1. Study of metaphase chromosomes from permanent slides.
2. Study of various stages of meiosis from permanent slides.
3. Extraction/Isolation of genomic DNA and RNA from mammalian blood
4. Restriction digestion of with restriction enzymes; Agarose Gel Electrophoretic analysis of DNA, and RNA.
5. Sub cellular fractionation of functional mitochondria
  - a. Isolation of mitochondria from mouse liver by differential centrifugation.
  - b. Identification of mitochondrial fraction by assay of marker enzyme.
6. Observation of DNA fragmentation in apoptotic cells and Principle of FACS.

## **Course code ZOOL 4005**

### **Laboratory I (ZOOL 4001 & ZOOL 4002)**

1. Study of Museum specimen and slides from different invertebrate phyla.
2. Preparation of the permanent slide of the material available.
3. Demonstration of digestive, reproductive and nervous system of Cockroach.
4. Mounting of:Body setae of *Earthworm*, Mouth part of insects, Salivary gland of Cockroach, Invertebrate larvae.
5. Collection and identification of invertebrates in pond water.
6. Field study report.



7. Taxonomic identification using keys
8. Preparation of models showing the status of certain taxa or species in a given habitat
9. Calculation of Biodiversity indices for a given habitat (grassland, arid land, and wetland):
  - a. Shannon-Weiner species diversity index
  - b. Shannon evenness index
  - c. Simpson dominance index
  - d. Species richness, species evenness, and Relative abundance, Community evenness
  - e. Berger parker dominance
  - f. Bray-Curtis index of dissimilarity
10. Influence of climatic conditions on taxonomic diversity in a given habitat
11. Data collection, management and analysis
12. Calculation of central tendency & Dispersion
13. Hypothesis testing (t-test, Chi-square test)
14. R x C Contingency table
15. Bivariate statistics
16. Probability
17. Non-parametric statistics

**Course code ZOOL 4006**

**Laboratory II (ZOOL 4003 & ZOOL 4004)**

1. Field work to understand ecological concepts.
2. To determine population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
3. To study different types of survivorship curves from hypothetical/real data provided.
4. To analyze soil/pond biota
5. To determine dissolved oxygen and pH of different water samples,
6. To visit National Park/Biodiversity Park/Wild life sanctuary and prepare report.
7. Study of metaphase chromosomes from permanent slides.
8. Study of various stages of meiosis from permanent slides.
9. Extraction/Isolation of genomic DNA and RNA from mammalian blood
10. Restriction digestion of with restriction enzymes; Agarose Gel Electrophoretic analysis of DNA, and RNA.
11. Sub cellular fractionation of functional mitochondria
  - a. Isolation of mitochondria from mouse liver by differential centrifugation.
  - b. Identification of mitochondrial fraction by assay of marker enzyme.
12. Observation of DNA fragmentation in apoptotic cells and Principle of FACS.

**Semester II**  
**Core course ZOOL 4007**  
**Chordates: Structure, Function and Evolutionary Significance**

**UNIT I**

Origin, affinity and systematic position of Protochordates, Hemichordates, Urochordates, Cephalochordates, Anatomical, developmental and molecular evidence, Inter-relationship, Structural organizations, Feeding habit and role of endostyle, Retrogressive metamorphosis, Agnatha and Gnathostomata, Cyclostomes.

**UNIT II**

**Pisces:** Respiration: Branchial, Integumentary; Dipnoi and accessory respiratory modifications, Lateral-line sensory system, locomotion: body/caudal fin propulsion, median/paired fin propulsion, Dynamic lift, Hydrodynamics, flight, walking, burrowing, larval fish locomotion; migration: Shaoling, schooling, Anadromous, catadromous, diadromous, amphidromous, potamodromous, oceanodromous, Osmoregulation.

**Amphibia:** Origin of tetrapods, Stem tetrapods, Carboniferous-Jurassic Labyrinthodonts, Antracosauroids, Lepospondyls, body structural organization, Modern lissamphibia, Metamorphosis: mechanisms, endocrine control, morphological, biochemical changes, molecular response, Neoteny and paedogenesis, parental care.

**UNIT III**

**Reptilia:** Origin of reptiles, skull types, Limb diversity and digit reduction in evolution of reptiles, Adaptive radiation in reptiles, Diversity, Mesozoic world of dinosaurs: Saurischians and Ornithischians diversity, extinction, Changes in traditional classification of reptiles, Affinity and systematic position of *Sphenodon*, *Seymouria*, Squamates: Lizards and snakes, Poisonous and non-poisonous snakes, biting mechanism, venoms, anti-venoms.

**UNIT IV**

**Aves:** Origin and evolution of Birds, Archaeopteryx as connecting link between reptiles and aves, Flying and flightless birds, Distribution of flightless birds, flight adaptation: morphology, anatomy, physiology and biochemistry and flying mechanism: Aerodynamic principle and Biomechanics, types of flight: gliding, skimming, flapping, soaring, hovering, migration: types, pattern, control, navigation, adaptation, threat.

**UNIT V**

**Mammalia:** Origin and evolution of mammals, Habitat and different mode of adaptation, Geographic range, Diversity, dentition: structure, types and modes of classification, unusual teeth, egg laying mammals: natural history, paleontology and classification, fossil monotremes, pouched-mammals: classification, phylogeny, aquatic mammals: classification, adaptation,

geographic range and diversity, primates: classification, anatomy, morphology, physiology, behaviour.

### List of recommended books:

1. Booloottian, R. A. and Stiles, K. A., College Zoology, 10<sup>th</sup> edition, Macmillan Publishing Co., Inc. New York, 1981.
2. Colbert, E. H., Morales, M. and Minkoff, E. C. Colbert's Evolution of the Vertebrates: A history of the backboned animals through time, 5<sup>th</sup> edition, John Wiley - Liss, Inc., New York, 2002.
3. Farner, D. S. and King, J. R., Avian Biology (in several volumes), Academic Press, New York, 1971.
4. Goodrich, E. S., Studies on Structure and Development of Vertebrates, Dover Publication, New York, 1958.
5. Hildebrand, M. Analysis of Vertebrate Structure, 4<sup>th</sup> edition, John Wiley & Sons, Inc., New York, 1995.
6. Jordan, E. L. and Verma, P. S., Chordate Zoology. S. Chand & Company Ltd, 1998.
7. Kotpal, R. L. The Birds, 4<sup>th</sup> edition, Rastogi Publications, Shivaji Road, Meerut, 1999.
8. Marshall, A. J., Biology and Comparative Physiology of Birds, Volume I & II, 1960.
9. McFarland, W. N., Pough, F. H., Cade, T. J. and Heiser, J. B., Vertebrate Life, Macmillan Publishing Co., Inc., New York, 1979.
10. Moore, J. A., Biology of Amphibia, Academic Press, 1964.
11. Parker, T. S. and Haswell, W. A., TextBook of Zoology, Vol. II, ELBS, 1978.
12. Romer, A. S. and Parsons, T. S., The vertebrate body, 6<sup>th</sup> edition, CBS Publishing Japan Ltd, 1986.
13. Sinha, A. K., Adhikari, S. and Ganguli, B. B.: Biology of Animals, Vol. II, New Central Book Agency, Calcutta, 1988.
14. Young, J. Z. The life of vertebrates, 3<sup>rd</sup> edition, ELBS with Oxford University Press, 1981.

### Practicals:

1. Museum specimens and slides: *Salpa* (asexual & sexual), *Botyillus*, *Herdmania*
2. *Amphioxus*: External features, study of velum, oral hood, and pharyngeal wall through permanent slides
3. *Chimera*, *Acipenser*, *Amia*, *Periophthalmus*, *Tricanthus*, *Notopterus*, *Exocoetus*, *Diodon*
4. *Icthyophis*, *Rhacophorus*, *Ambystoma*, *Rana*
5. Study of feathers, types of beaks, types of eggs, types of nests
6. Study of vertebrae and skeleton system, skull and lower jaw
7. Study of VS of skin of : Bony fish (scaly & scaleless), frog, reptile, bird and mammals
8. Mounting: Placoid, Cycloid and Ctenoid scales
9. Accessory respiratory organs of *Clarias*, *Heteropneusters*, *Ophiocephalus*
10. Air-sacs in *Columba*
11. Histology: Study of permanent slides of following tissues and organs of mammals; Tooth, tongue, Oesophagus, stomach, intestine, pancreas, liver, spleen, kidney, cartilage, bone

**Core course ZOOL 4008**  
**Biochemistry and Metabolism**

**UNIT I**

**Concept of cellular energetics:** Law of thermodynamic, internal energy, enthalpy, entropy, concept of free energy, standard free energy change of a chemical reaction, redox potentials, ATP and high energy phosphate compounds. Properties of water, acids and bases. Water in cell environment, salts, electrolytes, pH, Henderson–Hasselbach equation, buffers, buffering capacity and Zwitter-ions, Physiological buffering systems.

**UNIT II**

**Structure and Function of Biomolecules:** Carbohydrates - Classification, structure and properties, chemical reactions, derived sugars. Amino acids and Proteins – Structure, classification and properties, non-protein amino acids, essential amino acids, amphoteric properties of amino acids, dissociation, chemical reactions; Proteins; Structural organization; Primary, Secondary, Tertiary and Quaternary structure, Ramachandran Plot. Lipids – Classification, structure, fatty acids, phospholipids, sphingolipids, glycolipids and steroids, chemical reactions. Nucleic acids- Structure and properties of RNA and DNA. Watson – Crick model of DNA, Polymorphism in DNA Structure.

**UNIT III**

**Metabolism of Biomolecules:** Concept of metabolism, Oxidation–reduction reactions, basic concepts of metabolic energy, capture and transfer.

**Carbohydrates:** Glycogenolysis, glycogenesis, regulation of glycogen metabolism, glycolysis, TCA cycle, fermentation reactions, glyoxylate cycle, pentose phosphate pathway.

**Proteins and amino acid metabolism:** Oxidative degradation of amino acids : Proteolysis, Transamination, oxidative deamination, acetyl CoA and oxaloacetate pathway, decarboxylation, urea cycle,.

**Lipids:** Fatty acid metabolism, Beta oxidation of saturated and unsaturated fatty acids, the phases of fatty acid oxidation, energetics of beta oxidation.

**Nucleic acids:** Biosynthesis of purines and pyrimidines, Vitamins

**UNITS IV**

**Enzymes:** History, classification and nomenclature, specificity of enzyme; Kinetics of enzyme catalyzed reaction - Chemical kinetics, Michaelis–Menten equation, Line-weber Berk Plot, quantitative assay of enzyme activity, factors affecting enzyme activity, Ribozyme.

**Mechanism** of enzyme action – Hypothesis, catalytic mechanism, acid base and covalent

**Clinical aspects of enzymology:** LDH isozymes, SGOT, SGPT, creatine kinase, alpha amylase, phosphatase, inborn errors.

## UNITS V

### **Metabolic Disorder and Secondary metabolite:**

Metabolic disorders of Carbohydrates, Proteins, Lipids and Nucleotides.

**Integration of Metabolism:** Metabolic network - Interrelationship of metabolisms Krebs cycle, amino acid synthesis, Nucleotide biosynthesis.

**Secondary metabolism-** Classification and role of secondary metabolites of plants and microbes.

### **List of recommended books:**

1. Principles of Biochemistry –Lehninger
2. Metabolic Pathways - Greenberg.
3. Biochemistry – G. Zubay, Addison Wesley Publ. (1983).
4. Biochemistry – Stryer (1988) 3rd Edition W.H. Freeman
5. Physical Biochemistry by D. Freifelder IInd Edition (1982)
6. Biochemistry with clinical correlation- Thomas Devlin, 2nd ed, John Wiley and sons
7. Practical Biochemistry, Principles and Techniques (1995). Ed. Keith Wilson and John Walker
8. Harper's Illustrated Biochemistry, Murray, Granner and Rodwell, (27th Ed.), McGraw Hill, New York, USA 3
9. Biochemistry, Voet D., AND J. G. Voet, Jon Wiley and Sons Inc., USA

### **Practicals:**

1. Verification of Beer Lambert Law using any color solution.
2. Preparation of buffers and determination of pH.
3. Quantitative estimation of carbohydrate, total protein and lipid, cholesterol, DNA and RNA.
4. Chemical analysis of urine for the presence of urea, sugar, proteins and ketone bodies.
5. Determination of protein by PAGE.
6. Analysis of enzyme activities of LDH, alkaline phosphatase,  $\alpha$ -amylase.
7. Effect of pH, heat and salt on enzyme activity.

## **Core course ZOOL 4009**

### **Animal Physiology**

## **UNIT I**

### **Animal Form and Function and Digestive system**

**Homeostasis:** Animal form and function, levels of organization, Bioenergetics, homeostasis, thermoregulation: body temperature–physical, chemical, neural regulation, acclimatization, torpor. **Digestive system:** Intracellular and Extracellular digestion, absorption of carbohydrates, fats, proteins, enzymes and hormones in digestive process, energy balance.

## UNIT II

### **Blood and Cardiovascular System**

**Blood:** Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, haemostasis.

**Cardiovascular System:** Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, neural and chemical regulation.

## UNIT III

### **Respiratory system and Nervous system**

**Respiratory system:** Anatomical considerations of **respiratory system**, transport of gases, exchange of gases, neural and chemical regulation of respiration. **Nervous system:** Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture, **Sense organs:** Vision, hearing and tactile response.

## UNIT IV

### **Excretory system**

Anatomical considerations of kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.

## UNIT V

### **Endocrinology and reproduction**

Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation.

### **List of recommended books:**

1. Guyton and Hall textbook of medical physiology by Hall, John E. and Guyton, Arthur C. Published by Elsevier (Philadelphia), 2011.
2. Barrett, Kim E.: Gangong's review of medical physiology by Publication Tata McGraw Hill, 2012.
3. David Randall, Warren Burggren, and Kathleen French., WH Freeman: Eckert Animal Physiology: Mechanisms and Adaptations, Fifth Edition.
4. Kandel ER, Schwartz JH, Jessell TH: Principles of neural science, 4th edition. New York: McGraw-Hill, 2000. \* Please refer to latest editions available.

## **Practicals:**

1. To determine blood group.
2. To count the total RBC in blood using haemocytometer.
3. To measure blood pressure by sphygmomanometer.
4. To stain neurons/glia by using Golgi-Cox and other available staining methods
5. To stain cheek epithelial cells with methylene blue.
6. To measure the sugar level in blood.
7. To observe mammalian slides/PPT for oesophagus, liver, spleen, lung, kidney, spinal cord and ovary.

## **Core course ZOOL 4010** **Cytogenetics and Genetics**

### **UNIT I**

**Inheritance biology:** Mendelian principles: Dominance, segregation, independent assortment, Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, Epistasis, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy

### **UNIT II**

**Concept of gene:** Allele, multiple alleles, pseudoallele, complementation tests, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

**Gene mapping methods:** Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.

### **UNIT III**

**Extra chromosomal inheritance:** Inheritance of Mitochondrial and Chloroplast genes, maternal inheritance.

**Microbial genetics:** Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

### **UNIT IV**

**Quantitative genetics:** Concept, Genes and Environment - heritability, its measurements, penetrance and expressivity, Polygenic inheritance, heritability and, QTL mapping

**Biochemical genetics:** disorders of folate and cobalamin transport and metabolism, lysosomal storage disease, peroxisome disorders, genetics of lipoproteins and human disease, genetics of steroid receptors, genetics of collagen and mitochondrial disease

### **UNIT V**

**Immunogenetics:** Genetic basis of structure and diversity of immune response proteins, Immunoglobulin gene superfamily, Genetic basis of antibody diversity  
TCR gene loci: genetic basis of TCR diversity  
HLA locus: genetic polymorphism and HLA haplotypes  
Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.  
Basic concepts of molecular detection of genetic disorders and gene therapy

### **List of Recommended Books**

1. Basic Human Genetics: Mange and Mange, Sinauer Assoc
2. The Principles of Clinical Cytogenetics: Gersen & Keagle , Humana
3. Human Molecular Genetics 4th Ed.: Strachan and Read, Wiley
4. An Introduction to Molecular Human Genetics: Pasternak , Fitzgerald
5. Molecular Biology in Medicine: Cox and Sinclair, Blackwell
6. Genes in Medicine: Rasko and Downes, Kluwer
7. Principles & Practice of Medical Genetics : Rimoin et al, Churchill
8. Clinical Genetics Handbook: Robinson and Linden, Blackwell
9. Molecular Biotechnology : Primrose, Panima
10. Molecular Cloning: Sambrook et al, CSHL
11. Gene Cloning and DNA Analysis - An Introduction: T.A. Brown, Blackwell

### **Practicals:**

1. Study and demonstration of law of segregation
2. Study and demonstration of law of independent assortment
3. Study and demonstration of Linkage and crossing-over
4. Competent cell preparations, storage and transformation in *E.coli*
5. Study and demonstration of Conjugation and transduction
6. Construction of Pedigree
7. Study of biochemical and genetic disorders through slides, models, and charts etc
8. Human karyotypes

**Course code ZOOL 4011**

**Swayam Course**

As per the UGC guidelines



## **Course code ZOOL 4012**

### **Laboratory I (ZOOL 4007 & ZOOL 4008)**

1. Museum specimens and slides: Salpa (asexual & sexual), Botyillus, Herdmania
2. Amphioxus: External features, study of velum, oral hood, and pharyngeal wall through permanent slides
3. Museum specimens : Chimera, Acipencer, Amia, Periophthalmus, Tricanthus, Notopterus, Exocoetus, Diodon
4. Museum specimens : Ichthyophis, Rhacophorus, Ambystoma, Rana
5. Study of feathers, types of beaks, types of eggs, types of nests
6. Study of vertebrae and skeleton system, skull and lower jaw
7. Study of VS of skin of : Bony fish (scaly & scaleless), frog, reptile, bird and mammals
8. Mounting: Placoid, Cycloid and Ctenoid scales
9. Accessory respiratory organs of Clarias, Heteropneusters, Ophiocephalus
10. Air-sacs in Columba
11. Histology: Study of permanent slides of following tissues and organs of mammals; Tooth, tongue, Oesophagus, stomach, intestine, pancreas, liver, spleen, kidney, cartilage, bone
12. Verification of Beer Lambert Law using any color solution.
13. Preparation of buffers and determination of pH.
14. Quantitative estimation of carbohydrate, total protein and lipid, cholesterol, DNA and RNA.
15. Chemical analysis of urine for the presence of urea, sugar, proteins and ketone bodies.
16. Determination of protein by PAGE.
17. Analysis of enzyme activities of LDH, alkaline phosphatase,  $\alpha$ -amylase.
18. Effect of pH, heat and salt on enzyme activity.

## **Course code ZOOL 4013**

### **Laboratory II (ZOOL 4009 & ZOOL 4010)**

1. To determine blood group.
2. To count the total RBC in blood using heamocytometer.
3. To measure blood pressure by sphygmomanometer.
4. To stain neurons/glia by using Golgi-Cox and other available staining methods
5. To stain cheek epithelial cells with methylene blue.
6. To measure the sugar level in blood.
7. To observe mammalian slides/PPT for oesophagus, liver, spleen, lung, kidney, spinal cord and ovary.
8. Study and demonstration of law of segregation
9. Study and demonstration of law of independent assortment
10. Study and demonstration of Linkage and crossing-over
11. Competent cell preparations, storage and transformation in *E.coli*
12. Study and demonstration of Conjugation and transduction

13. Construction of Pedigree
14. Study of biochemical and genetic disorders through slides, models, and charts etc
15. Human karyotypes

## Semester III

### Core Course ZOOL 4014 DEVELOPMENTAL BIOLOGY

#### UNIT I

**Different approaches to understand developmental biology:** History and basic concepts, Anatomical, Evolutionary, Genetic, Signaling pathways, and experimental approaches. **Model organisms:** *C. elegans*, *Drosophila*, *Zebrafish*, *Mice*. Applications of model organisms in medical sciences.

#### UNIT II

**Fundamentals of development:** Potency, commitment, induction, competence, specification, determination and differentiation, morphogenetic gradients, cell fate and cell lineages, , genomic equivalence and the cytoplasmic determinants. Types of specification: autonomous and conditional.

#### UNIT III

**Early embryonic development in animals:** Production of gametes, cell surface molecules in sperm-egg recognition in animals, slow block and fast block to polyspermy, zygote formation, Types of eggs and various cleavage patterns, fate maps, morula formation, blastula formation, gastrulation and formation of germ layers, Morphogenesis: Cell adhesion and cell migration, cell aggregation and differentiation in *Dictyostelium*, Genetics of axis specification in *Drosophila*, role of maternal genes, homeobox concept, axes and pattern formation in sea urchin, *amphibians*, *chick* and *mammals*.

#### UNIT IV

**Late embryonic development:** Vulva formation in *Caenorhabditis elegans*, development of limb in vertebrates: Involvement of HOX and other pattern forming genes, Neurogenesis and formation of neural tube in vertebrates, development of heart, and eye in vertebrates.

#### UNIT V

**Post Embryonic development:** Metamorphosis in insects and amphibian. Hormonal regulation of metamorphosis, Regeneration- epimorphic regeneration of *Salamander* limb.requirement of nerves for the proliferation of blastema cells; embryonic stem cells and their applications; Growth and Ageing. Teratogenesis-genetic and environmental.

### **List of recommended books:**

1. Gilbert, S.F. 2000. Developmental Biology. Sixth edition. INC Publishers, USA.
2. Westhoff, P. 1998. Molecular Plant Development: from gene to plant. The Bath Press, UK.
3. Wolpert, L. 2001. Principles of Development. Second Edition. Oxford Univ. Press, UK.
4. Turnbull, G.N. (Ed.) 2005. Plant Architecture and its Manipulation, ARPP Rev. Vol.17, Blackwell Publ. CRC Press, USA.

### **Practicals:**

1. Study of the developmental stages of *Caenorhabditis elegans*.
2. Study of frog, hen and/ rat development through prepared permanent slides.
3. Study of different types of eggs
4. Observation of rat/frog sperm and ova
5. Window making: To study development of chick and blastoderm mounting.
6. Project report.

## **Core Course ZOOL 4015** **Evolution Biology**

### **UNIT I**

**History of Evolution:** Emergence of evolutionary thoughts Lamarck; Darwin—concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis

### **UNIT II**

**Origin and Evolution of life:** Origin of cells and unicellular evolution: Origin of basic of biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiments of Miller (1953); The first cell; Evolution of prokaryotes; Origin and evolution of eukaryotic cells.

### **UNIT III**

**Paleontology and Evolutionary History:** The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Stages in primate evolution including Homo.

**Micro Evolution:** Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches)

### **UNIT IV**

**The Mechanisms of Evolution:** Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Genetic polymorphism; Convergent evolution; Sexual selection; Co-evolution.

## UNIT V

**Molecular Evolution:** Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence.

### **List of recommended books:**

1. Dobzhansky Th. (1964): Genetics and the Origin of Species. Columbia.
2. Dobzhansky Th. et al. (1976): Evolution. Surjeet Publ. ( 34 )
3. Freeman S. and Jon C. Herron (1998): Evolutionary Analysis. Prentice Hall
4. Futuyma D. J. (1998): Evolutionary Biology. Sinauer
5. Hartl D. L. and A. G. Clark (1989 & 1997): Principles of Population Genetics. Sinauer
6. Kimura M. (1984): The Neutral Theory of Molecular Evolution. Cambridge.
7. Li Wen-Hsiung and Dan Graur (1991): Fundamentals of Molecular Evolution. Sinauer
8. Mayr E. (1966): Animal Species and Evolution. Belknap Press
9. Ridley M. (1993): Evolution. Blackwell.
10. Strickberger M. W. (2000): Evolution. Jones and Bartlett
11. White M. J. D. (1978): Modes of Speciation. Freeman

### **Practicals:**

1. Demonstration of chromosomal and isozyme polymorphism in some insect populations
2. Exercises based on Hardy-Weinberg equilibrium
3. Demonstration of changes in gene and genotype frequencies through natural selection, genetic drift, mutation and migration
1. Genetic drift: Quantification; Measurement of diversity and population subdivision
2. Quantifying Kin selection and coefficient of relatedness
3. Demonstration of mating patterns/preferences and sexual selection
4. Demonstration of reproductive isolation through *Drosophila* and peaks & valleys; Allele frequency changes through isolating mechanisms
5. Demonstration of adaptive radiation as exemplified by Galapagos finches and its origin and ancestry
6. Demonstration of modes of speciation, clines & Ring species: Development, structure and character
7. Construction of phylogenetic trees using distance-matrix (UPGMA) and discreet data methods (maximum parsimony and maximum likelihood)
8. Adaptive molecular evolution: Adaptive protein evolution detected by neutrality tests
9. Exercises based on the calculation of rate of molecular evolution
10. Protein and nucleotide sequence analysis using online sequencing tools

**Core Course ZOOL 4016**  
**Immunology**

**UNIT I**

**Introduction to immune system:** Origin of immune system of vertebrates. **Innate & adaptive immune system:** Pathogen recognition receptors (PRR/TLR), PAMP, DAMP. Haematopoiesis; Concept of Inflammation; Cells and molecules involved in innate and adaptive immunity; Primary and Secondary lymphoid organs Concept of humoral and cell-mediated immunity. Active and passive immunity.

**UNIT II**

**Antigen:** Characteristics of ideal antigen; Classification of antigen; Concept of hapten and Adjuvant, Antigenic determinants /epitope; Antigenicity and immunogenicity.

**Antibody:** Basic structure of immunoglobulin; types and subtypes of immunoglobulin; Functions of Immunoglobulins; Isotypic, allotypic and idiotypic variations, Production of polyclonal and monoclonal antibodies and its applications, Generation of antibody diversity.

**Common immunological tests used in diagnosis of microbial and parasitic diseases:** Radio-immunoassay, ELISA, Western Blotting, fluorescent-labeled immunological tests, agglutination and protection tests.

**UNIT III**

**Antigen recognition by B cell:** B-cell receptors (BcR). Antibody mediated effector functions. Class Switch, Clonal selection theory

**Antigen recognition by T cell:** Structure of T cell receptor; Receptor diversity; Gene regulating TCR; T cell activation and differentiation

**UNIT IV**

**Major Histocompatibility Complex Molecule:** General features of MHC. Structure and classification of MHC; Cellular distribution; MHC polymorphism; endocytic and exocytic pathway; Role of MHC in transplantation.

**Cytokine and chemokines:** Cytokine Structure and Function; Cytokine producing cells, Role of cytokine in immune regulation, Chemokines.

**Complement System:** basic concept of complement; Classification of complement, Complement structure, Complement activation pathways: classical, lectin and alternative pathways.

**UNIT V**

Tolerance and Activation of Immune System: Immunological tolerance. Immunosuppression; Hypersensitivity and its types; Autoimmunity and autoimmune disorders.

**Immune response to diseases:** Viral, Bacteria and protozoal diseases; Concepts of vaccines, whole-organism vaccines, recombinant vaccines, DNA vaccine, synthetic peptide and multivalent sub unit vaccines.

**List of recommended books:**

1. Coleman, R.M, “Fundamental Immunology”
2. Richard A. Goldsby Thomas J. Kindt Janis Kuby Barbara A. Osborne “Immunology”.
3. Peter Parkham Peter Parham “The Immune System”.
4. Abul K Abbas, Andrew H. Lichtman, Abdul K. Abbas, Jordan S. Pober “Cellular & Molecular Immunology”
5. Janeway Charles A., Travers Paul, Walport Mark, Shlomchik Mark, Immunobiology

**Practicals:**

1. Agar gel immunodiffusion assay
2. Ochterlony double diffusion assay for antibody titration
3. Blood group analysis by agglutination
4. Demonstration of Indirect ELISA
5. Identification of various immune cells by morphology – Leishman staining, Giemsa staining.
6. Dot-ELISA for detection of antigen antibody interaction
7. Project work

**Major Elective I\*: Course code ZOOL 4017**

- Cytogenetics I: Basic and Applied Cytogenetics
- Cancer Biology I: Basics of Cancer Biology
- Wildlife Biology I: Indian Wildlife
- Neurobiology I
- Entomology I
- Molecular Endocrinology I

**Will consider later:**

- Neurobiology I
- Entomology I
- Molecular Endocrinology I

## **Major Elective I\*: Course code ZOOL 4017**

### **Cytogenetics I: Basic and Applied Cytogenetics**

#### **UNIT-I**

**Eukaryotic chromatin structure and chromosome organization, Chromosomal proteins:** histones and their modifications, non-histone proteins, scaffold/matrix proteins. levels of chromatin condensation at interphase and metaphase stages, nuclear matrix and organization of interphase nucleus centromere, kinetochore and telomere, metaphase chromosome bandings

#### **UNIT-II**

**Eukaryotic Genome:** C-value Paradox, Repetitive DNA, General Concept of a Gene, Gene Families, Non-Coding Genes

**Screening and Characterization of Clones:** Preparation of Probes, Principles of Hybridizations and Hybridization Based Techniques (Colony, Plaque, Southern, Northern and In situ Hybridizations), Expression based Screening

**Interaction based Screening:** Yeast Two-Hybrid System

#### **UNIT-III**

**Giant chromosomes:** models for studies on chromosome organization and gene expression

**Cell division:** Role of maturation promoting factor, Chromosomal movement, Exit from mitosis, Cytokinesis, Meiosis: Chromosome pairing and recombination, Genetic regulation of meiosis

#### **UNIT-IV**

**Human cytogenetics:** Karyotype and nomenclature of metaphase chromosome bands, Chromosome anomalies and disease. Common syndromes caused by aneuploidy, mosaicism, deletion and duplication. Chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilms' tumour). Fragile site and X-linked mental retardation

#### **UNIT-V**

**Monogenic Traits:** Autosomal Inheritance-Dominant and Recessive; Sex-Linked Inheritance, Sex-Limited and Sex-Influenced Traits, Mitochondrial Inheritance, MIM Number. Complications to the Basic Pedigree Patterns- Non-penetrance, Variable, Expressivity, Pleiotropy, Late Onset, Dominance problems, Anticipation, Genetic Heterogeneity, Genomic Imprinting and Uniparental Disomy, Mosaicism and Chimerism, Male Lethality, X-inactivation. Risk Assessment: Application of Bayes' Theorem, Allele Frequency in Population, Consanguinity and its Effects

### **:List of recommended Books**

12. Basic Human Genetics: Mange and Mange, Sinauer Assoc
13. The Principles of Clinical Cytogenetics: Gersen & Keagle , Humana
14. Human Molecular Genetics 4th Ed.: Strachan and Read, Wiley
15. An Introduction to Molecular Human Genetics: Pasternak , Fitzgerald
16. Molecular Biology in Medicine: Cox and Sinclair, Blackwell
17. Genes in Medicine: Rasko and Downes, Kluwer
18. Principles & Practice of Medical Genetics : Rimoin et al, Churchill
19. Clinical Genetics Handbook: Robinson and Linden, Blackwell
20. Molecular Biotechnology : Primrose, Panima
21. Molecular Cloning: Sambrook et al, CSHL
22. Gene Cloning and DNA Analysis - An Introduction: T.A. Brown, Blackwell

### **Practicals:**

1. Sex-linked inheritance
2. Lethal gene markers
3. Linkage map, cytogenetic mapping: Physical maps and molecular maps; Strategies of different level of molecular mapping
4. Probability exercises and its applications in the analysis of genetic data
5. Chi-square and its application in the analysis of genetic data
6. Estimation of gene and genotypic frequencies of genetic traits in humans
7. Construction of filial pedigree
8. Preparation of Competent cells (DH5 $\alpha$ , XL1BL, TOP10F', BL21 (DE3))
9. Transformation, Conjugation and Transduction
10. ELISA: Quantification of immunogenicity of conjugated and non-conjugated peptides
11. Design, expression, purification and characterization of Scfv and Scfab

## **Course code ZOOL 4017**

## **Cancer Biology I: Basics of Cancer Biology**

### **UNIT I**

**Cancer:** Definition, causes, properties, classification, prevalence, clonal nature. Cancer risk factors: Theory of carcinogenesis, Chemical carcinogenesis, Physical carcinogenesis: x-ray radiation – mechanisms of radiation carcinogenesis. Etiology of cancer: Stages of cancer: initiation, promotion, progression. Carcinogenesis. Prevalence of cancer in India and World.

### **UNIT II**

**Cancer metastasis:** Clinical significances of invasion – Heterogeneity of metastatic phenotype – Metastatic cascade: basement membrane disruption, invasion – Recent approach to identify key factors controlling metastasis – Angiogenesis. Cancer stem cell and role of EMT in cancer metastasis.



### UNIT III

**Molecular oncology:** Oncogenes and Tumor suppressor genes: Retroviral oncogenes, Proto-oncogenes, Function and roles of oncogenes and tumor suppressor genes in tumor development. Cancer and Apoptosis: Genetics of cell death, Bcl-2 family, role of apoptosis in tissue homeostasis, caspases. Cell Cycle: Loss of check points control and genetic instability in cancer, Replicative senescence.

### UNIT IV

**Cancer cell signaling and gene regulation:** Signal transduction pathways (GPCR, TGF $\beta$ , Ras, STAT and RTK signaling), apoptotic pathways, signal molecules, effects on receptor. Alteration of signaling pathways in cancer cells. Autophagy. Transcriptional, post-transcriptional, and post-translational regulation of oncogenes and tumor suppressor genes.

### UNIT V

**Genetic basis of Cancer:** Basic concepts of cancer genetics, types of genetic risk factors for Cancer. Cancer Genomics: Cancer Genome database, analysis and application. Chromosomal abnormalities in cancer.

#### **List of recommended books:**

1. Cancer Biology (Authors: Raymond W. Ruddon)
2. The Biological Basics of Cancer (Author: *Robert Gilmore McKinnell et al*)
3. Principles of Cancer Biology (Author: Lewis J. Kleinsmith)
4. Biology of Cancer (Authors: Lobo D)
5. Weinberg R.A. Biology of Cancer. Taylor and Francis Inc.

#### **Practicals:**

1. Histological observation of preparation of cancer vs normal tissues.
2. Maintenance of cancer cell lines.
3. Cytotoxicity assay for cancer vs normal cells.
4. Apoptotic assays.
5. Cell viability assay.
6. Preparation and comments on micronuclei induced by carcinogens.
7. Study of chromosomal aberrations induced by carcinogens.
8. Project work.

## Course code ZOOL 4017

### Wildlife Biology I: Indian wildlife

#### **UNIT I**

**Indian wildlife:** History and cultural background of Indian Wildlife Needs and values of wildlife protection, Types of wildlife management, Significance of wildlife conservation, Management policies and their implementation, Factors injurious to wildlife and forests, Invasive species and its threat to native species.

#### **UNIT II**

**Wildlife techniques:** Data collection; monitoring; Methods of population surveys: Counts (Direct count - Total counts, Drive counts, Time Area counts, Indirect counts - Call counts, Track counts), Line transect estimate, Indices and Mark recapture estimate, Direct and indirect evidences, census methods, Pellet counts: Mark-recapture method - Peterson or Lincoln index method. Environmental impact assessment (EIA), Geographic Information System (GIS), radio telemetry.

#### **UNIT III**

**Zoogeographical regions of India and their fauna:** Himalayan, Eastern and Western ghats, Thar, Deccan plateau, Gangetic plains. Fauna of India. Status, distribution, physical characteristics and ethology of: Tiger, Lion, Rhinoceros, Elephant, Mugger, Four-horned Antelope. Status, distribution, physical characteristics threatened species.

#### **UNIT IV**

**Special Wildlife programs:** Project Tiger, Project Elephant, Operation Rhino, Project Crocodile, Wildlife of India, Ramsar convention, Ramsar sites of India (Chilka lake, Bhoj Wetland, Wular Lake, Deepor Beel, Point Calimere Wildlife and Bird Sanctuary).

#### **UNIT V**

**Wildlife Institutes in India:** WII, BNHS, ZSI, IIFM, FSI, CAZRI, Central Zoo Authority of India Wildlife legislation: Wildlife Protection Act, 1972; National Wildlife Action Plan, 2002; National Biodiversity Act, 2002.

#### **List of recommended books:**

1. Wildlife biology by Raymond F. Dasmann.
2. WILDLIFE BIOLOGY: AN INDIAN PERSPECTIVE by Goutam Kumar Saha and SUBHENDU MAZUMDAR.
3. Wildlife Management and Conservation: Contemporary Principles and Practices by Paul Krausman.
4. Becoming a Wildlife Professional by Scott E. Henke, Paul R. Krausman.

**Practicals:**

1. Determination of species dominance and frequency using quadrant/plot method.
2. Designing the animal housing, enclosures and kraal.
3. Study of different types of cages.
4. POP preparation of pugmarks and footprints.
5. Bird watching and identification of resident and migratory birds.
6. Study of social organization of mammals.
7. Study of an approach to rescue of wild animals
8. Visit to a wetland/pond/lake/river: study of aquatic animal. Student should submit the report on the study.

**ZOOL 4018: Swayam Course**

As per UGC guide lines

**ZOOL 4019  
Laboratory I (ZOOL 4014, 4015 and 4016)****ZOOL 4014**

1. Study of the developmental stages of *Caenorhabditis elegans*.
2. Study of frog, hen and/ rat development through prepared permanent slides.
3. Study of different types of eggs
4. Observation of rat/frog sperm and ova
5. Window making: To study development of chick and blastoderm mounting.
6. Project report.

**ZOOL 4015**

1. Demonstration of chromosomal and isozyme polymorphism in some insect populations
2. Exercises based on Hardy-Weinberg equilibrium
3. Demonstration of changes in gene and genotype frequencies through natural selection, genetic drift, mutation and migration

- a. Genetic drift: Quantification; Measurement of diversity and population subdivision
- b. Quantifying Kin selection and coefficient of relatedness
- c. Demonstration of mating patterns/preferences and sexual selection
4. Demonstration of reproductive isolation through *Drosophila* and peaks & valleys; Allele frequency changes through isolating mechanisms
5. Demonstration of adaptive radiation as exemplified by Galapagos finches and its origin and ancestry
6. Demonstration of modes of speciation, clines & Ring species: Development, structure and character
7. Construction of phylogenetic trees using distance-matrix (UPGMA) and discrete data methods (maximum parsimony and maximum likelihood)
8. Adaptive molecular evolution: Adaptive protein evolution detected by neutrality tests
9. Exercises based on the calculation of rate of molecular evolution
10. Protein and nucleotide sequence analysis using online sequencing tools

### **ZOOL 4016**

1. Agar gel immunodiffusion assay
2. Ouchterlony double diffusion assay for antibody titration
3. Blood group analysis by agglutination
4. Demonstration of Indirect ELISA
5. Identification of various immune cells by morphology – Leishman staining, Giemsa staining.
6. Dot-ELISA for detection of antigen antibody interaction
7. Project work

### **ZOOL 4020: Laboratory II (ZOOL 4017)** **Cytogenetics I: Basic and Applied Cytogenetics**

1. Sex-linked inheritance
2. Lethal gene markers
3. Linkage map, cytogenetic mapping: Physical maps and molecular maps; Strategies of different level of molecular mapping
4. Probability exercises and its applications in the analysis of genetic data
5. Chi-square and its application in the analysis of genetic data
6. Estimation of gene and genotypic frequencies of genetic traits in humans
7. Construction of filial pedigree
8. Preparation of Competent cells (DH5 $\alpha$ , XL1BL, TOP10F', BL21 (DE3))
9. Transformation, Conjugation and Transduction
10. ELISA: Quantification of immunogenicity of conjugated and non-conjugated peptides
11. Design, expression, purification and characterization of Scfv and Scfab

### **Cancer Biology I: Basics of Cancer Biology**

1. Histological observation of preparation of cancer vs normal tissues.

2. Maintenance of cancer cell lines.
3. Cytotoxicity assay for cancer vs normal cells.
4. Apoptotic assays.
5. Cell viability assay.
6. Preparation and comments on micronuclei induced by carcinogens.
7. Study of chromosomal aberrations induced by carcinogens.
8. Project work

### **Wildlife Biology I: Indian wildlife**

1. Determination of species dominance and frequency using quadrant/plot method.
2. Designing the animal housing, enclosures and kraal.
3. Study of different types of cages.
4. POP preparation of pugmarks and footprints.
5. Bird watching and identification of resident and migratory birds.
6. Study of social organization of mammals.
7. Study of an approach to rescue of wild animals
8. Visit to a wetland/pond/lake/river: study of aquatic animal. Student should submit the report on the study.

## Semester IV

### Core Course ZOOL 4021

#### Animal Behaviour

##### UNIT I

**Introduction of Animal Behaviour:** Definition, historical outline, patterns of behaviour, objectives of behaviour, mechanism of behaviour, approaches and methods in study of behavior

**Behavior of Individual animals:** Food findings, predators, prey defense, orientation and migration, navigation and homing.

##### UNIT II

**Animal relationships:** Communications, aggregation, courtship, parental behaviour, habitat selection and optimality in foraging, domestication and behavioral changes, frequency and density dependent selection.

**Altruism:** Reciprocal altruism, group selection, kin selection and inclusive fitness, cooperation, alarm call

##### UNIT III

**Parental care:** Parental manipulation, evolutionarily stable strategy, cost benefit analysis of parental care with suitable case studies.

**Sexual selection:** Intra sexual selection, male rivalry, inter-sexual selection, female choice, Mating systems, parental investment and reproductive success, infanticide, sperm competition, mate guarding, monogamous versus polygamous sexual conflict.

##### UNIT IV

**Brain and Behaviour:** Neural basis of learning, memory, cognition, conditioning, habituation, sensitization, reasoning, social communication, social dominance, use of space and territoriality, development of behavior.

**Biological Clocks:** Introduction of Chronobiology, circadian rhythms, genes responsible for circadian clocks, molecular mechanisms that allow circadian clocks.

##### UNIT V

**Reflexes Behaviour:** Reflex action, types of reflexes, reflex arch, characteristics of reflexes and complex behaviour.

**Sleep and wake Behaviour:** States of consciousness- sleep-wakefulness behaviour, identification and, classification of sleep-wakefulness, neural and neurochemical regulation of sleep-wakefulness, effects of sleep loss.

**List of recommended books:**

1. Animal Behaviour by Reena Mathur, Rastogi Publication.
2. Campbell, N.A. and Reece, J.B.: Biology, Ninth edition Pearson Benjamin Cummings, San Francisco.
3. Arora, D.R. and Arora B.(2001) Medical Parasitology. II edition.CBS Publications and Distributers.
4. Drickamer&Vessey: Animal Behaviour – concepts, processes and methods (2nd ed. 1986,Wadsworth,)
5. Goodenough et al.: Perspectives on Animal Behaviour (1993, Wiley)
6. Manning & Dawkins: An Introduction to Animal Behaviour (5th ed. 1998, Cambridge).

**Practicals (ZOOL: 4025, LAB I):**

1. Locomotry behaviour of *Caenorhabditis elegans* after exposure of different chemicals
2. Effect of light intensity on the rate of *Caenorhabditis elegans* locomotion
3. To study the responses of wood lice to hygrostimuli.
4. To study the phototaxis and geotaxis behaviour of earthworm.
5. To study the social behaviour of Honey bee, Ant and Termite.
6. To study the behavioural patterns of Wasps and their nests.
7. To study the habituation in snail.
8. To study the nesting behaviour of birds.
9. To study Circadian rytham (body temperature, blood pressure etc.)
10. Visit to a zoological garden/ wildlife sanctuaries / natural habitats specially Bihar. Student should submit the report on the study covering various aspects of animal behaviour observed.

**Core Course ZOOL 4022**

**Core Course ZOOL 4022: Animal Biotechnology**

**UNIT I**

**Animal Biotechnology and its scope :** Principles of sterile techniques and cell propagation, Cell culture media, Serum free media; Types of cell culture system: monolayer culture, Roller bottle, Suspension culture, static suspension culture, agar culture, agitated micro carrier suspension culture, hollow fiber systems, Scaling up factors. Organotypic cultures, Bioartificial Organs.

**UNIT II**

**Primary Cell Culture:** isolation of tissue,, isolation of cells from explants by enzymatic disaggregation, mechanical disaggregation. Steps involved in primary cell culture, Cell line characterization: Morphology, Chromosome Analysis, Antigenic Markers, Immortalization, Cell counting, Generation Time. Measurement of cell growth and viability, cell synchronization, cell

transformation, cryo-preservation and application of cell cultures. Types of microbial contamination and Eradication of Contamination

### **UNIT III**

**Mammalian Cell Lines:** Mammalian cell expression system, gene transfer techniques, Stem cell: principles for identification, characterization of differentiated cell types, purifications, assessment of proliferation heterogeneity, long-term maintenance and characterization, Embryonic and adult stem cells and their applications.

### **UNIT IV**

**Transgenic animals:** Animal virus vectors; Shuttle vectors. Knock in and knock out models, Cloning of animals, Integration of DNA into mammalian genome; Transgenic animal as bioreactors, low faults of transgenic animals; Applications of transgenic animals;.

### **UNIT V**

**Gene Therapy:** Ex-vivo gene therapy, In vivo gene therapy, Prodrug activation therapy, Nucleic acid therapeutic agents. Protein production by genetically engineered mammalian cell lines, Manipulation of Growth hormone: somatotropic hormone, Thyroid hormone and animal vaccines; Probiotics as growth promoters, Ideal characteristics probiotics, uses of probiotics.

#### **List of recommended books:**

1. T A Brown “Gene Cloning: An introduction”
2. R. Ian Freshney “Culture of Animal Cells”
3. J.M. Davis “Animal Cell Culture”
4. Gerald Karp “Cell and Molecular Biology: Concepts and Experiments”
5. Verma and Singh “Animal Biotechnology: Models in discovery and Translation”
6. Masters J.R.W. Animal Cell Culture: Practical Approach. Oxford University Press.2000

#### **Practicals**

1. Laboratory design and Instrumentation in Animal Tissue Culture Lab
2. Preparation of media for the given animal cell culture.
3. Mechanical isolation of primary cells from animal tissues
4. Maintenance of primary cells for 72 hrs
5. Maintenance of established cell lines.
6. Cell counting & viability by vital staining.
7. Plating of cells in 24 well culture plate and incubation for 24hrs.
8. MTT assay for cell viability and proliferation



## **Major Elective II\*: Course code ZOOL 4023**

- Cytogenetics II: Human cytogenetics
- Cancer Biology II: Advanced Cancer biology
- Wildlife Biology II: Conservation and Management
- Neurobiology II
- Entomology II
- Molecular Endocrinology II

### **Will consider later:**

- Neurobiology II
- Entomology II
- Molecular Endocrinology II

## **Course code ZOOL 4023** **Cytogenetics II: Advanced cytogenetics**

### **UNIT I**

**General features of Human Chromosome:** Chromatin structure, Constitutive and Facultative Heterochromatin, Centromeres, Telomere and its maintenance, Nuclear Organization Region (NOR), Sister Chromatid Exchanges (SCE) and its significance, Mosaicism, Structure of Human X and Y chromosome and Human Artificial Chromosome.

### **UNIT II**

**Cytogenetic and Molecular Cytogenetic Techniques:** Karyotyping and its significance Banding techniques (G, Q, T, R, etc). Studies of polytene chromosomes. Chromosome break points mapping: Deletion mapping, translocation mapping, Inversion mapping.

### **UNIT III**

Chromosomal rearrangements and their cytogenetic consequences with examples from *Drosophila* and Man, Practical applications of chromosome rearrangements - Balancers and attached X-chromosome in *Drosophila*. Structure of Human X and Y chromosome and Human Artificial Chromosome. Cytogenetic and linkage maps, Two and three point cross in *Drosophila*, RFLP mapping.

### **UNIT-IV**

**Common chromosomal disorders and Mendelian disorders:** Down syndrome, Edwards syndrome, Patau's syndrome and other trisomies, Structural aberrations, Single gene disorders: autosomal and sex chromosomal, Multifactorial disorders.

### **UNIT-V**

**Clinical Cytogenetic and it's Applications:**

Prenatal and pre-implantation diagnosis: Non-invasive: Triple test, Ultrasonography Ultrasonography (USG) Invasive: Amniocentesis (AC), chorionic villi sampling (CVS), Fetal blood sampling (FBS). Population screening for genetic disorders Treatment and management of genetic disorders. Thalassaemia, Fanconi anemia, Sickle Cell anemia, Fragile-X syndrome, Alzheimer's disease.

**List of recommended books:**

1. Gillham, N. (2011). Genes, Chromosomes and Disease. Pearson.
2. Hein, S. and Mitelman, F. (2009). Cancer Cytogenetics. Wiley-Blackwell.
3. Kumar, A. and Srivastava, M. (2012) A textbook of Molecular Cytogenetics, Narendra Publishing House, India.
4. Purandare, H. and Chakravarty, A. (2000), Human Cytogenetic Techniques and Clinical Applications. Bhalani Publishing House, Mumbai, India.
5. Ram, M. (2010). Fundamental of Cytogenetics and Genetics. PHI Learning Pvt. Ltd.
6. Human Chromosomes Authors: Orlando J. Miller &Eeva Therman 4th edition.
7. Chromosome Techniques (Third Edition) Theory and Practice Author(s): Arun Kumar Sharma and Archana Sharma.

**Practicals:**

1. Culture of Peripheral Blood Lymphocytes for Chromosome preparation
1. Karyotyping of normal and abnormal chromosome sets.
1. Identification of inactivated X chromosome as Barr body and drumstick.
1. Chromosome banding.
1. Analysis of Human Karyotype in different diseases.
1. Preparation of mini project proposal.

**Major Elective II\***

**Course code ZOOL 4023**

**Cancer Biology II: Advanced Cancer Biology**

**UNIT I**

**Cancer Epigenomics:** Epigenetic process, modifications and gene expression: DNA methylation, Histone modifications, Non-coding RNAs in Epigenetics, epigenetic modifications to chromatin remodeling and transcription, Role of epigenetic events in cancer- initiation, and progression.

**UNIT II**

**Virus and cancer:** Viruses and oncogene, tumor virus and human cancer, oncogenic RNA viruses, retroviruses, DNA tumor viruses, *Human papilloma virus*, *Herpes virus*, *Kaposi sarcoma virus*, *Hepatitis virus*, *Epstein barr virus*. Virus co-factors.

### **UNIT III**

**Cancer Metabolism:** An Introduction to Cancer Metabolism, Warburg Effect, altered metabolism in cancer cells, energetic of cell proliferation, imaging cancer metabolism in patients, molecular mechanism of metabolism in Cancer, targeting cancer metabolism.

### **UNIT IV**

**Molecular diagnosis of cancer:** Prediction of aggressiveness of cancer, cell free DNA detection makers, NGS in cancer detection, epigenetic biomarkers and FISH, Mutation analysis, Single Nucleotide polymorphism assays, Real-Time PCR assays, Tissue Arrays: Tissue microarray-construction, visualization, analysis, Tissue microarray applications.

### **UNIT V**

**Cancer Screening and therapeutics:** Definition and principle of cancer screening, cancer screening program, Evaluating Screening test for specific cancers.

Classical Therapy: Surgery, chemotherapy and , radiation therapy for cancer. Drug resistance. and Drug Resistances, Epigenetic therapy.

New approaches of cancer therapy: Stem cell therapy, hormone therapy, herbal therapy, immunotherapy of cancer.

#### **List of recommended books:**

- Cancer Biology (Authors: Raymond W. Ruddon)
- The Biological Basics of Cancer(Author:*Robert Gilmore McKinnell et al*)
- Principles of Cancer Biology(Author:Lewis J. Kleinsmith)
- Biology of Cancer (Authors: Lobo D)

#### **Practicals:**

1. . Study of chromosomal aberrations induced by carcinogens.
2. Bioinformatic analysis of cancer database.
3. In silico primer designing for PCR and qRT-PCR.
4. Promoter mapping of tumor suppressor genes and proto oncogenes.
5. Expression analysis of cancer genes.
6. Presentation of research paper.
7. Preparation of the project report.

**Course code ZOOL 4023**  
**Wildlife Biology II: Conservation and Management**

**UNIT I**

Concepts of biodiversity, levels of biodiversity biological, genetic, species and ecosystem diversity, Types of species: Key stone species, Umbrella species, Indicator species, Flagship species, Exotic, Indigenous and Introduced species, Value of biodiversity direct and indirect economic values, ethical values; Threats to biodiversity habitat destruction, fragmentation and degradation, introduction, overexploitation

**UNIT II**

Introduction to conservation biology, conservation of biodiversity patterns and processes in situ and ex situ conservation, international conservation bodies IUCN, UNDP, FAO, WWF *Ex situ* conservation role of zoos and aquariums, introduction/reintroduction and translocation *In situ* conservation national parks and wildlife sanctuaries formation and management, protection and administration. Human-animal conflict.

**UNIT III**

National parks of India Ranthambore, Ghana, Kaziranga, Kanha, Bandipur, Gir, Corbett, Silent Valley; Marine National Parks of India Mannar, Gulf of Kutch. Biospheres of India and their concept. Wildlife Sanctuaries in India.

**UNIT IV**

IUCN categories in context to Indian Wildlife (Extinct, Extinct in wild, critically endangered, endangered, vulnerable, near threatened, least concern, data deficient and not evaluated). Endangered and threatened animals - Mammals, Birds, reptiles.

**UNIT V**

Captive breeding and propagation: rehabilitation, gene banks Wildlife forensics: DNA banks for endangered animals; Pug mark analysis, Hair analysis Conservation ethics and values. Need of Social forestry programs, Involvement of common people, Extension and education, tourism, finance in wildlife management. Genetic drift and its effect on loss of genetic variation: implication on biodiversity.

**List of recommended books:**

1. Wildlife biology by Raymond F. Dasmann.
2. WILDLIFE BIOLOGY: AN INDIAN PERSPECTIVE by Goutam Kumar Saha and SUBHENDU MAZUMDAR.
3. Wildlife Management and Conservation: Contemporary Principles and Practices by Paul Krausman.
4. Becoming a Wildlife Professional by Scott E. Henke, Paul R. Krausman.

**Practicals:**

1. To observe foraging behavior in local wild animals.
2. Taxonomic identification and preparation of taxonomic key of given animals.
3. Review of zoo-working plans and maps.
4. Demonstration of equipment's and used in capturing and handling of wild animals.
5. Knowledge of tags, collars, radio-tracking equipment's; biological sampling, preservation and transport of samples.
6. Socioeconomic survey based on questionnaire related to wild animals in local areas.
7. Research paper presentation of any topic from the syllabus.
8. Visit to a zoological garden. Student should submit the report on the study covering various aspects like animals observed, their food preparation and presentation.

**ZOOL 4024: Dissertation****Course code ZOOL 4025: Laboratory I****Animal Behaviour**

1. Locomotry behaviour of *Caenorhabditis elegans* after exposure of different chemicals
2. Effect of light intensity on the rate of *Caenorhabditis elegans* locomotion
3. To study the responses of wood lice to hygrostimuli.
4. To study the phototaxis and geotaxis behaviour of earthworm.
5. To study the social behaviour of Honey bee, Ant and Termite.
6. To study the behavioural patterns of Wasps and their nests.
7. To study the habituation in snail.
8. To study the nesting behaviour of birds.
9. To study Circadian rytham (body temperature, blood pressure etc.)
10. Visit to a zoological garden/ wildlife sanctuaries / natural habitats specially Bihar. Student should submit the report on the study covering various aspects of animal behaviour observed.

**Animal Biotechnology**

1. Laboratory design and Instrumentation in Animal Tissue Culture Lab
2. Preparation of media for the given animal cell culture.
3. Mechanical isolation of primary cells from animal tissues
4. Maintenance of primary cells for 72 hrs
5. Maintenance of established cell lines.
6. Cell counting & viability by vital staining.
7. Plating of cells in 24 well culture plate and incubation for 24hrs.
8. MTT assay for cell viability and proliferation

**Course code ZOOL 4026: Laboratory II (Major Elective)**  
**Cytogenetics II: Advanced cytogenetics**

1. Culture of Peripheral Blood Lymphocytes for Chromosome preparation
2. Karyotyping of normal and abnormal chromosome sets.
3. Identification of inactivated X chromosome as Barr body and drumstick.
4. Chromosome banding.
5. Analysis of Human Karyotype in different diseases.
6. Preparation of mini project proposal.

**Cancer Biology II: Advanced Cancer Biology**

1. Study of chromosomal aberrations induced by carcinogens.
2. Bioinformatic analysis of cancer database.
3. In silico primer designing for PCR and qRT-PCR.
4. Promoter mapping of tumor suppressor genes and proto oncogenes.
5. Expression analysis of cancer genes.
6. Presentation of research paper.
7. Preparation of the project report.

**Wildlife Biology II: Conservation and Management**

1. To observe foraging behavior in local wild animals.
  2. Taxonomic identification and preparation of taxonomic key of given animals.
  3. Review of zoo-working plans and maps.
  4. Demonstration of equipment's and used in capturing and handling of wild animals.
  5. Knowledge of tags, collars, radio-tracking equipment's; biological sampling, preservation and transport of samples.
  6. Socioeconomic survey based on questionnaire related to wild animals in local areas.
  7. Research paper presentation of any topic from the syllabus.
  8. Visit to a zoological garden. Student should submit the report on the study covering various aspects like animals observed, their food preparation and presentation.
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