

# **PDM UNIVERSITY**

## **Faculty of Life Sciences**

**Department of Zoology**

**M.Sc. Zoology**

**TWO YEAR FULL TIME PROGRAMME**



**PDM UNIVERSITY BHADURGARH**

**DELHI- NCR**

*Note: Syllabi applicable for students seeking admission in the M.Sc. Zoology  
Course from the academic year 2020 onwards*

## Details of Course: M.Sc. Zoology

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### Course Structure Credits (Theory + Practical)

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Core Courses (14 Papers)	10 x 04 = 40
Core Course Practicals (10)	10 x 02 = 20
Elective Courses (4 Papers)	04 x 04 = 16
Elective Courses Practicals (2)	02 x 02 = 04
Dissertation (Experimental, Presentation and Viva-Voce)	01 x 16 = 16

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**Total Credits = 96**

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**M.Sc. Zoology**  
**Department of Zoology**  
**Faculty of Life Sciences,**  
**PDM University**

**PROGRAMME STRUCTURE**

	Module Code	Module Type	Module Name	Marks			Credits
				Internal	External	Total	
<b>1<sup>st</sup> Sem</b>	ZOOL5101	Core I	Genetics and Cytogenetics	50	100	150	4
	ZOOL5102	Core I (P)	Genetics and Cytogenetics Lab	25	50	75	2
	ZOOL5103	Core II	Principles of Gene Manipulation	50	100	150	4
	ZOOL5104	Core II (P)	Principles of Gene Manipulation Lab	25	50	75	2
	ZOOL5105	Core III	Comparative Animal Physiology	50	100	150	4
	ZOOL5106	Core III (P)	Comparative Animal Physiology Lab	25	50	75	2
	ZOOL5107	Core IV	Metabolism: Concepts and Regulation	50	100	150	4
	ZOOL5108	Core IV (P)	Metabolism: Concepts and Regulation Lab	25	50	75	2
				<b>Total</b>	<b>300</b>	<b>600</b>	<b>900</b>
<b>2<sup>nd</sup> Sem</b>	ZOOL5109	Core V	Developmental Biology	50	100	150	4
	ZOOL5110	Core V (P)	Developmental Biology Lab	25	50	75	2
	ZOOL5111	Core VI	Systematics, Biodiversity and Evolution	50	100	150	4
	ZOOL5112	Core VI (P)	Systematics, Biodiversity and Evolution Lab	25	50	75	2
	ZOOL5113	Core VII	Immunology	50	100	150	4
	ZOOL5114	Core VII (P)	Immunology Lab	25	50	75	2
	ZOOL5115	Core VIII	Molecular Cell Biology	50	100	150	4
	ZOOL5116	Core VIII (P)	Molecular Cell Biology Lab	25	50	75	2
				<b>Total</b>	<b>300</b>	<b>600</b>	<b>900</b>
<b>3<sup>rd</sup> Sem</b>	ZOOL6101	Core IX	Principles of Ecology	50	100	150	4
	ZOOL6102	Core IX (P)	Principles of Ecology Lab	25	50	75	2
	ZOOL6103	Core X	Computational Biology, Biostatistics and Bioinformatics	50	100	150	4
	ZOOL6104	Core X (P)	Computational Biology, Biostatistics and Bioinformatics Lab	25	50	75	2
	ZOOL6201/ ZOOL6203/ ZOOL6205	Elective I	Elective-I	50	100	150	4
	ZOOL6202/ ZOOL6204/ ZOOL6206	Elective I (P)	Elective-I Lab	25	50	75	2
	ZOOL6207/	Elective II	Elective-II	50	100	150	4

	ZOOL6209/ ZOOL6211						
	ZOOL6208/ ZOOL6210/ ZOOL6212	Elective II (P)	Elective-II Lab	25	50	75	2
			<b>Total</b>	<b>300</b>	<b>600</b>	<b>900</b>	<b>24</b>
<b>4<sup>th</sup> Sem</b>	ZOOL6213/ ZOOL6215/ ZOOL6217/ ZOOL6219	Elective III	Elective-III	50	100	150	4
	ZOOL6214/ ZOOL6216/ ZOOL6218/ ZOOL6220	Elective IV	Elective-IV	50	100	150	4
	ZOOL6221	Core	Dissertation (Experimental, Presentation and Viva-Voce)	400	400	800	16
			<b>Total</b>	<b>500</b>	<b>600</b>	<b>1100</b>	<b>24</b>
			<b>Grand Total after four semesters</b>	<b>1400</b>	<b>2400</b>	<b>3800</b>	<b>96</b>

\*Elective III and Elective IV will be from the same stream

### List of Elective Courses in 3<sup>rd</sup> Semester:

#### Group A Elective I

1. ZOOL6201 Biology of Parasitism
2. ZOOL6203 Chronobiology
3. ZOOL6205 Protein Structure, function and Evolution

#### Group B Elective II

1. ZOOL6207 Structure and function of gene
2. ZOOL6209 Animal Behaviour
3. ZOOL6211 Comparative Endocrine Physiology

### List of Elective Courses in 4<sup>th</sup> Semester:

Student will select anyone of the four streams, each stream consisting of two papers

#### Stream 1

- |   |           |  |
|---|-----------|--|
| 1 | ZOOL 6213 | <b>Entomology</b><br>Insect Diversity, Society and Evolution |
| 2 | ZOOL 6214 | Insect Toxicology and Ecology                                |

#### Stream 2

- |   |          |  |
|---|----------|--|
| 1 | ZOOL6215 | <b>Fish Biology</b><br>Diversity and Behaviour of Fishes |
| 2 | ZOOL6216 | Aquatic Resources and their Conservation                 |

#### Stream 3

- |   |          |   |
|---|----------|---|
| 1 | ZOOL6217 | <b>Genome and Evolution</b><br>Genomics |
|---|----------|---|

2            ZOOL6218            Microbiome

**Stream 4**

**Molecular Endocrinology and  
Reproduction**

1            ZOOL6219            Neuroendocrinology

2            ZOOL6220            Biology of Pregnancy, Parturition and  
Lactation

**Dissertation is compulsory for all the students in the IV Semester**

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**Genetics and Cytogenetics (ZOOL5101)  
Theory**

**Unit 1.** Mendel's laws and their chromosomal basis; extension of Mendel's principles: allelic variation and gene function- incomplete dominance and co-dominance, allelic series, testing gene mutations for allelism; gene action- from genotype to phenotype– penetrance and expressivity, gene interaction, epistasis, pleiotropy.

**Unit 2.** Nature of the gene and its functions: evolution of the concept of the gene, fine structure of gene

**Unit 3.** Linkage, Crossing Over and Chromosome Mapping in Eukaryotes: Methods of gene mapping: 3- point test cross in Drosophila, pattern of inheritance by pedigree analysis and gene mapping, Human genome and mapping.

**Unit 4.** Gene mutation, DNA repair and Recombination: types of gene mutations, methods for detection of induced mutations;

**Unit 5.** Mechanisms of sex determination and Dosage Compensation: Human, Drosophila and C. elegans.

**Unit 6.** Genetic analysis of complex traits - complex pattern of inheritance, quantitative traits, threshold traits.

**Unit 7.** Human genetics- Chromosome banding, karyotype and nomenclature of metaphase chromosome; chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilms' tumor); oncogenes and tumor suppressor genes- genetic pathways to cancer.

**Suggested Literature:**

1. Principles of Genetics, Snustad and Simmons, (4<sup>th</sup> Ed. 2005), John Wiley & Sons, USA
2. Modern Genetic Analysis: Integrating Genes and Genomes, Griffiths, J.F., Gelbart, M., Lewontin, C. and Miller, W. H. Freeman and Company, New York, USA
3. Genetics, J. Russell, Benjamin-Cummings Publishing Company, San Francisco, California, USA

## Genetics and Cytogenetics Lab (ZOOL5102)

### Practicals

1. Study of mutant phenotypes of *Drosophila*.
2. Demonstration of law of segregation using *Drosophila* mutants.
3. Study of law of independent assortment.
4. Demonstration of sex- linkage by using *white* mutation of *Drosophila*.
5. Demonstration of dosage compensation in *Drosophila* males and females.
6. Demonstration of Green Fluorescence and Red Fluorescence protein for monitoring gene expression.
7. Targeted tissue specific expression of a gene using UAS-Gal4 System in *Drosophila*.
8. Study of transcriptional activity in polytene chromosome upon heat shock induction by uridine incorporation.
9. Study of sex chromatin in buccal smear and hair bud cells (Human).
10. Study of Hardy– Weinberg equilibrium in human population by taking the example of blood group system (ABO).

## **Principles of Gene Manipulation (ZOOL5103)**

### **Theory**

Basic recombinant DNA techniques, cutting and joining DNA molecules, restriction modification systems, various enzymes used in recombinant DNA technology, restriction maps and mapping techniques; nucleic acid probes, blotting techniques, DNA fingerprinting, footprinting, methyl interference assay. Polymerase chain reaction—methods and applications.

Basic biology of cloning vectors: plasmids, phages, single stranded DNA vectors, high capacity vectors, retroviral vectors, expression vectors and other advanced vectors in use. Gene cloning strategies: methods of transforming *E. coli* and other cells with rDNA; methods of selection and screening of transformed cells; construction of genomic and cDNA libraries; strategies of expressing cloned genes; phage display.

Principles of DNA sequencing, automated sequencing methods; synthesis of oligonucleotides, primer design; micro-arrays; confocal microscopy; changing genes- directed evolution, protein engineering in microbes .

Manipulating genes in animals: gene transfer to animal cells, genetic manipulation of animals, transgenic technology, application of recombinant DNA technology; genetically modified organisms: gene knockouts, mouse disease models, gene silencing, gene therapy, somatic and germ- line therapy.

### **Suggested Literature:**

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R. M., (7<sup>th</sup> Ed. 2006), Blackwell Publishing, West Sussex, UK
3. Molecular Biotechnology: Principles and application of recombinant DNA, Bernard R. and Jack, ASM Press, Herndon, USA

## **Principles of Gene Manipulation Lab (ZOOL5104)**

### **Practicals**

1. Plasmid DNA isolation: minipreps.
2. Agarose gel electrophoresis of isolated plasmid.
3. DNA quantization and purity of DNA.
4. Restriction enzyme digestion of plasmid DNA.
5. Purification of DNA from an agarose gel.
6. Vector and insert ligation.
7. Preparation of competent cells and storage.
8. Transformation of *E. coli* with standard plasmids, calculation of transformation efficiency.



# Comparative Animal Physiology (ZOOL5105)

## Theory

Internal Transport and Gas Exchange – Systems of circulation, Peripheral circulation, Regulation of heart beat and blood pressure, Transport and exchange of gases, Neural and chemical regulation of respiration, Gas transfer in air and water, Gas exchangers, Circulatory and respiratory responses to extreme conditions, Acid – base balance, Regulation of body pH.

Osmoregulation – Osmoregulation in aquatic and terrestrial environments, Kidney functions and diversity, Extra-renal osmoregulatory organs, Patterns of nitrogen excretion. Thermoregulation - Heat balance in animals, Adaptations to temperature extremes, torpor, Aestivation and hibernation, Counter current heat exchangers. Adaptations to Stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance, stress and hormones.

Sensing the Environment- heat reception, chemoreception, mechanoreception, echolocation, Endogenous and exogenous biological rhythms, Chromatophores and bioluminescence.

Feeding mechanisms and their control, effect of starvation. Muscle physiology – striated and smooth muscle, Adaptations of muscles for various activities, Neuronal control of muscle contraction, Electric organs.

## Suggested Literature:

1. General and Comparative Animal Physiology, Hoar W. S. (ed), Prentice Hall, India
2. Comparative Physiology (Handbook of Physiology): Vol. 1, 2, Dantzler, W.H. (ed.) Oxford University Press, New York, USA
3. Animal Physiology: Adaptation and Environmental, Nelson K. S. (ed) Cambridge University Press, Cambridge, UK

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## Comparative Animal Physiology Lab

(ZOOL5106)

### Practicals

1. Observe and compare the inherent rhythmicity of the different parts of the heart.
2. Determine the effects of application of parasympathetic or sympathetic agonists/ antagonists.
3. Assessing physical and chemical modifiers of heart rate in frog.
4. Determine the response of the heart to direct electrical stimulation / vagal stimulation.
5. Effects of drugs and hormones on contraction of smooth muscles.

6. Demonstration of tetany, action current and fatigue in muscle.
7. To study the effect of load on muscle contraction.
8. Concentration / dispersal of pigment in isolated scales of dark / light adapted fish.
9. To determine the median threshold concentration of sucrose for housefly population.

## **Metabolism – Concepts and Regulation (ZOOL5107)**

### **Theory**

- Unit 1. Energetics and Design of Living Systems:** The living state, metabolism as the defining characteristic of living organisms, Bioenergetics (second law of thermodynamics, Free Energy and standard free energy change), synthesis of ATP, structure and function of electron transport chain.
- Unit 2. Catalysis and its Regulation:** Nature of enzymes – kinetics, reaction mechanism of chymotrypsin and lysozyme, Inhibition of Enzyme activity, regulation of enzyme activity.
- Unit 3. Metabolic Pathways and its Network:** A broad outline of metabolic pathways and their linkage, metabolism of primary metabolites – monosaccharaides, lipids and essential amino acids
- Unit 4. Metabolic Reprogramming:** Dynamic state of body constituents, experimental approaches to study metabolism, Metabolic basis of nutrition, metabolic basis of specialized tissue function, metabolic disorders, metabolic basis of diagnostics, metabolism and adaption , regulation of metabolism at cellular and organismic levels.

### **Suggested Literature:**

1. Lehningers Principles of Biochemistry, Nelson and Cox, Sixth Edition or recent edition, Macmillan Press.
2. Principles of Biochemistry, Voet, Voet and Pratt, 5<sup>th</sup> edition (2012) or recent edition, Wiley.
3. Harper's Illustrated Biochemistry, Murray, Granner and Rodwell, (27th Ed.), McGraw Hill, New York, USA.
4. Practical Biochemistry – Principles and Techniques, Wilson and Walker, Cambridge University Press, Cambridge [Latest edition].

## **Metabolism – Concepts and Regulation Lab (ZOOL5108)**

### **Practicals**

1. Titration of an amino acid, an acidic dye and an organic acid to determine the pKa value.
2. Preparation of a 'Good' buffer.
3. Biomolecules.
4. Sub- cellular fractionation of rat liver and marker enzyme assays.
5. Purification of any one enzyme to homogeneity.
6. Characterization of a purified protein/ enzyme for homogeneity by HPLC-GPC, molecular size by SDS-PAGE and post-translational modification by MALDI-TOF.
7. Estimation of a sugar, an amino acid, a vitamin, a nucleotide/nucleic acid by appropriate chemical and biological methods.
8. Kinetic characterization of any one enzyme.
9. Determination of energy of activation for an enzyme mediated reaction.
10. Surviving tissue technique and metabolic labeling using radioisotope containing precursor.
11. Enzymes as drug targets- a selected example.
12. Zymogram for any one enzyme.
13. Immobilization of an enzyme and its study.
14. Affinity chromatography using either a lectin or a textile dye.
15. Allosteric regulation of an enzyme activity.
16. Histochemical localization of a dehydrogenase.

**Semester –II**  
**Developmental Biology (ZOOL5109)**

**Theory**

History and basic concepts: the origin of developmental biology- cell theory, mosaic and regulative development, discovery of induction, genetics and development; basic concepts of developmental biology- cell division, cell differentiation, signaling, patterning; model systems: vertebrates model organism- *Xenopus laevis*, chicken, mammals, zebrafish; invertebrate model organism- *Drosophila melanogaster*, *Caenorhabditis elegans*; identification of developmental genes: spontaneous and induced mutation, mutant screening, developmental mutations in *Drosophila*.

Early embryonic development of vertebrates and invertebrates: structure of the gametes– the sperm, the egg; cleavage and gastrulation; axes and germ layers; morphogenesis– cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation, cell migration; Axis specification in *Drosophila*; origin of anterior- posterior and dorsal- ventral patterning- role of maternal genes, patterning of early embryo by zygotic genes; segmentation genes- the gap genes, the pair– rule genes, the segment polarity genes, the homeotic selector genes- bithorax and antennapedia complex.

General concepts of organogenesis: development of chick limb- development and patterning of vertebrate limb, proximal- distal and dorso- ventral axis formation, homeobox genes in patterning, signaling in patterning of the limb; insect imaginal disc– determination of wing and leg imaginal discs, organizing center in patterning of the wing, butterfly wing development, the homeotic selector genes for segmental identity;

Postembryonic development: growth- cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence; regeneration– epimorphic regeneration of reptile and salamander limb, requirement of nerves for the proliferation of blastema cells; embryonic stem cells and their applications; medical implications of developmental biology: genetic errors of human development- the nature of human syndromes– pleiotropy, genetic heterogeneity, phenotypic variability, mechanism of dominance; gene expression and human disease– inborn errors of nuclear RNA processing, inborn errors of translation; teratogenesis- environmental assaults on human development- teratogenic agents like alcohol, retinoic acid etc.

**Suggested Literature:**

1. Developmental Biology, Gilbert, (8<sup>th</sup> Ed., 2006) Sinauer Associates Inc., Massachusetts, USA.
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3<sup>rd</sup> Ed., 2006), Oxford University Press, New Delhi, INDIA.
3. Analysis of Biological Development, Kalthoff, (2<sup>nd</sup> Ed., 2000), McGraw-Hill Science, New Delhi, INDIA.

## Developmental Biology Lab (ZOOL5110)

### Practicals

1. Study of life cycle of *Drosophila melanogaster*.
2. Study of embryogenesis in *Drosophila* and pattern of gene
3. Immunohistochemical staining to study the expression pattern of gap and pair- rule gene proteins.
4. Dissection and study of larval and prepupal wing, leg and eye antennal imaginal discs of *Drosophila*.
5. Patterning of the adult wing and demonstration of the effect of cell death on the patterning of the adult wing.
6. Study of Homeotic gene mutations.
7. Influence of temperature and teratogenes on animal development.
8. Study of regeneration in *Hydra*.

## Systematics, Biodiversity and Evolution (ZOOL5111) Theory

- Unit 1.** **An overview of evolutionary biology:** concept of organic evolution during pre- and post- Darwin era; evolution and molecular biology- a new synthesis; from molecules to life, life originated from RNA, introns as ancient component of genes.
- Unit 2.** **The universal common ancestor and tree of life, three domain concept of living kingdom; molecular phylogeny:** history, terms, definition and limitations, construction of phylogenetic trees using molecular data, molecular divergence and molecular clocks and molecular drive; origin and diversification of bacteria and archea; diversification of genomes; the nature of bacterial and archeal genomes; role of plasmid and transposons in DNA transfer.
- Unit 3.** **Origin and diversification of eukaryotes:** origin of cells; evolution of eukaryotic cell from prokaryotes- a case of symbiosis; evolution of eukaryotic genomes; gene duplication and divergence.
- Unit 4.** **Mode of speciation:** factors responsible for speciation; systematics- definition and role in biology, biological classification- theories and objectives, types of taxonomy, taxonomic diversity- definition and types, origination and extinction, rates of change in origination and extinction, causes of extinction, causes of differential rates of diversification, current status and future of biodiversity; human evolution- human evolutionary history; placing humans on tree of life; genomics and humanness; current issues in human evolution.

### Suggested Literature:

1. Evolution, Barton, N. H., Briggs, D. E.G., Eisen, J. A., Goldstein, A. E., Patel, N. H., Cold Spring Harbor Laboratory Press, New York, USA
2. Evolution, Hall, B. K. and Hallgrimsson, B., Jones and Bartlett Publisher, Sudbury, USA
3. Evolution, Futuyma, D. J., Sinauer Associates, Inc., Sunderland, USA

**Systematics, Biodiversity and Evolution Lab (ZOOL5112)**  
**Practicals**

1. Isolation of Genomic DNA from a bacterium and its quantification.
2. Designing primers for 16S rRNA gene sequence.
3. Amplification of 16S rRNA gene sequences by using genomic DNA as well as by colony boiling method.
4. Purification of 16S rRNA gene.
5. Sequence of 16S rRNA gene; editing the sequence, multiple alignments, construction of phylogenetic trees and interpretation of results.
6. Dot blot hybridization of different eubacterial species and interpretation of results.

## **Immunology (ZOOL5113) Theory**

Overview of the immune system: components of the immune system, principles of innate and adaptive immunity, the recognition and effector mechanisms of the adaptive immunity- antigen and immunogenicity, clonal selection theory.

Antigen recognition by immune cells: Adaptive immunity- antibody structure, antigen recognition by B lymphocytes, TCR, antigen recognition by T- cells, co-receptors, structure and function of MHC complex; generation of lymphocyte antigen receptors- generation of diversity in immunoglobulins, T- cell receptor gene rearrangement, structural variations in immunoglobulin constant regions; antigen processing and presentation to T lymphocytes- antigen presenting cells, generation of T- cell receptor ligand, and MHC restriction, role of CD1 in antigen presentation; Innate Immunity- pattern recognition in the innate immune system, role of TLRs in innate immune response, complement and innate immunity, induced innate response to infection.

Effector mechanisms and regulation of immune responses: Signaling through immune system receptors- antigen receptor structure and signaling pathways, other signaling pathways that contribute to lymphocyte behavior; development and survival of lymphocytes- B lymphocyte development and survival, humoral immune response, T lymphocyte development and survival, production of effector T- cells, cytotoxic T- cell effector mechanisms; NK and NKT cell functions; mucosal immunity; immunological memory; regulation of immune response: cytokines and chemokines, complement system, leukocyte activation and migration, APC regulation of the immune response, T- cell mediated regulation of immune response, Immunological tolerance and energy.

Immunity in health and disease: introduction to infectious disease, innate immunity to infection, adaptive immunity to infection, evasion of the immune response by pathogens; immunodeficiency diseases- inherited immunodeficiency diseases, acquired immune deficiency syndrome; allergy and hypersensitivity- IgE and allergic reactions, hypersensitivity diseases; autoimmunity- responses to self antigens, transplant rejection- responses to alloantigens; manipulation of immune responses, vaccines; evolution of immune system- evolution of innate immune system, evolution of adaptive immune system.

### **Suggested Literature:**

1. Kuby Immunology, Richard, Thomas, Barbara, Janis, (5<sup>th</sup> Ed., 2003), W. H. Freeman and company, New York, USA.
2. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, (6<sup>th</sup> Ed., 2005), Garland Science Publishing, New York, USA.
3. Immunology, David, Brostoff and Roitt, (7<sup>th</sup> Ed., 2006), Mosby & Elsevier .



## **Immunology Lab (ZOOL5114)**

### **Practicals**

1. Dissection of primary and secondary immune organs from mice:
  - a. Preparation of single cell suspension from bone marrow and spleen (spleenocytes) of mice.
  - b. Cell counting and viability testing of the spleenocytes prepared.
  
2. Preparation and study of phagocytosis by splenic/peritoneal macrophages.
  
3. Raising polyclonal antibody in mice, serum collection and estimating antibody titre in serum by following methods:
  - a. Ouchterlony (double diffusion) assay for Antigen -antibody specificity and titre.
  - b. ELISA
  
4. Antibody purification from the serum collected from immunized mice: affinity purification/chromatography.
  
5. Immunoelectrophoresis.
  
6. Demonstration of Western blotting:
  - a. Protein estimation by Lowry's method /Bradford's method
  - b. SDS-PAGE.
  - c. Immunoblot analysis.

## **Molecular Cell Biology (ZOOL5115)**

### **Theory**

#### **Unit 1. Cytoskeleton in eukaryotic cell architecture and function -**

Recapitulation of the structure of the eukaryotic cell with emphasis on how it functions as a unit of life; Structure and dynamics of microfilaments; Organization of the cortical cytoskeleton; Actin cytoskeleton in cell shape, intracellular motility and cell locomotion; Microtubule structure, organization and dynamics; Role of microtubules in cell shape and mitosis; Structure and function of intermediate filaments.

#### **Unit 2. Biology of Cell membranes –**

Recapitulation of the plasma membrane; Mechanism of diffusion, facilitated diffusion, active transport with suitable examples; Movement of water; Ion movements and cell function; Bulk transport: Receptor mediated endocytosis; Protein sorting and targeting to organelles; Targeting of proteins to lysosomes for degradation; Molecular mechanism of the secretory pathway; Secretion of neurotransmitters.

#### **Unit 3. Life cycle of a cell –**

Cell cycle and its regulation; Commitment to cell division; Entry into and exit from the cell cycle; Checkpoints in the mammalian cell cycle; Turnover of cellular components; Degradation of cytosolic proteins; Mammalian cell culture and cytotoxicity.

#### **Unit 4. Organization of cells into tissues and cellular communication -**

Extracellular matrix; Cell- cell and cell-matrix adhesion; Cell junctions; Intercellular communication: Key concepts in cellular signaling mechanisms; Second messenger systems; G-protein coupled receptors; Receptor tyrosine kinases; MAP kinase cascade; Desensitization of receptors; Survival and death pathways.

#### **Suggested Literature:**

1. Molecular Cell Biology, Lodish et al., W.H. Freeman and Company (8<sup>th</sup> Ed. 2016)
2. Molecular Biology of the Cell, Alberts et al., W.W. Norton and Company (6<sup>th</sup> Ed. 2014)
3. Molecular Biology, Weaver R. F., McGraw-Hill Education (5<sup>th</sup> Ed. 2011)
- 4.

## **Molecular Cell Biology Lab (ZOOL5116)**

### **Practicals**

1. Sub cellular fractionation of functional mitochondria
  - a. Isolation of mitochondria from mouse liver by differential centrifugation.
  - b. Determination of protein yield in the fractions by Lowry method.
  - c. Identification of mitochondrial fraction by assay of marker enzyme.
2. Microtubules in vesicle transport in fish chromatophores.
3. Mammalian cell culture
4. Assessment of proliferation in cultured cells by MTT assay.
5. Over-expression and affinity purification of SH3-GST recombinant protein from bacterial cells.
6. Demonstration of protein-protein interaction between recombinant SH3-GST fusion protein and ovarian proteins by SDS-PAGE
7. Effect of protein synthesis/ DNA synthesis inhibitor on cell responses to a hormone.
8. Observation of DNA fragmentation in apoptotic cells.
9. Glut mediated transport of glucose across the plasma membrane in mammalian cells.
10. Electrophoretic mobility shift assay (EMSA) for Protein-DNA interactions.
11. Introduction to FACS analysis.

## Semester –III

### Principles of Ecology (ZOOL6101)

#### Theory

Introduction to ecology, evolutionary ecology, environmental concepts – laws and limiting factors, ecological models. Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, fertility rate and age structure. Competition and coexistence, intra-specific and inter-specific interactions, scramble and contest competition model, mutualism and commensalism, prey-predator interactions.

Nature of ecosystem, production, food webs, energy flow through ecosystem, biogeochemical cycles, resilience of ecosystem, ecosystem management. The biosphere, biomes and impact of climate on biomes.

Environmental Stresses and their management, global climatic pattern, global warming, atmospheric ozone, acid and nitrogen deposition, coping with climatic variations. Major classes of contaminants. Uptake, biotransformation, detoxification, elimination and accumulation of toxicants. Factors influencing bioaccumulation from food and trophic transfer. Pesticides and other chemical in agriculture, industry and hygiene and their disposal. Impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers of environmental health. Biodegradation and bioremediation of chemicals.

Biodiversity – assessment, conservation and management, biodiversity act and related international conventions. Sustainable development, natural resource management in changing environment. Molecular ecology, genetic analysis of single and multiple population, phylogeography, molecular approach to behavioural ecology, conservation genetics.

#### Suggested Literature:

1. Field Sampling: Principles and Practices in Environmental Analysis, Conklin, A.R. Jr., (2004), CRC Press.
2. Principles and Standards for Measuring Primary Production, Fahey, T.J. and Knapp, A.K., (2007), Oxford University Press, UK
3. Ecological Modeling, Grant, W.E. and Swannack, T.M., (2008), Blackwell.
4. Fundamental Processes in Ecology: An Earth system Approach, Wilkinson, D.M., (2007), Oxford University Press, UK

# Principles of Ecology Lab (ZOOL6102)

## Practicals

### Habitat studies:

1. Physical and chemical characteristics of soil.
2. Assessing influence of light, temperature and moisture on plant germination and growth/animal behavior and growth.
3. Assessing influence of soil nutrient status on plant germination and growth.

### Community/ecosystem studies:

1. Assessment of density, frequency and abundance of plants/animal in a community using various techniques i.e. transect, quadrat etc.
2. Comparison of stands/communities and ordination.
3. Profile diagrams.
4. Biomass and reproductive allocation under various environments.
5. Nutrient uptake and budget for various communities/Food chain assessment.
6. Decomposition of various organic matters and nutrient release mechanisms/role of arthropods and other micro-, and macrofauna in decomposition.
7. Understanding ecosystem succession by studying various stages of vegetation/community assemblages development.
8. Molecular techniques in laboratory.
9. Insect diversity in soil.

### Landscape studies:

1. Principles of GIS, GPS and RS technology.
2. Interpretation (visual and automated) of remote sensing information for landscape differentiation.

## Computational Biology, Biostatistics and Bioinformatics (ZOOL6103)

### Theory

Basic components of computers– hardware (CPU, input, output, storage devices), Software (operating systems), Application software; Introduction to MSEXCEL– use of worksheet to enter data, edit data, copy data, move data; Use of in- built statistical functions for computations of mean, S. D., correlation, regression coefficients etc., Use of bar diagram, histogram, scatter plots, etc., Graphical tools in EXCEL for presentation of data; Introduction to MS- WORD word processor– editing, copying, moving, formatting, table insertion, drawing flow charts etc; Introduction to Power Point, image and data handling.

Biostatistics- population, sample, variable, parameter, primary and secondary data, screening and representation of data, frequency distribution, tabulation, bar diagram, histograms, pie diagram, mean, median, mode, quartiles and percentiles, variance, standard deviation, coefficient of variation; Probability and distributions- definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability, examples- bernoulli, binomial, poisson and normal distributions; bivariate data- scatter plot, correlation coefficient (r), properties (without proof), interpretation of r, linear regression: Fitting of lines of regression, regression coefficient, coefficient of determination; hypothesis, critical region, and error probabilities, tests for proportion, equality of proportions, equality of means of normal populations when variances known and when variances are unknown: chi-square test for independence, P- value of the statistic, confidence limits, introduction to one way and two- way analysis of variance.

The era of computerized biology information, review of relevant definitions in molecular biology, overview of challenges of molecular biology computing, proteins, secondary structure and folding, RNA secondary structures, introduction to phylogenetic analysis; introduction to bioinformatics; introduction to genomics and proteomics databases- nucleic acid sequence database: Genbank, UCSC, ENSEMBL, EMBL, DDBJ, protein sequence databases: Swiss- prot, PDB, BLAST, PSI- BLAST (steps involved in use and interpretation of results) and HMMER, BLAST vs FASTA, file formats- FASTA, GCG and ClustalW.

Databank search- data mining, data management and interpretation, multiple sequence alignment, genes, primer designing; Protein modeling, protein structure analysis, docking, ligplot interactions, phylogenetic analysis with the program PHYLIP, DISTANCES, GROWTREE etc.; introduction to computational genomics and proteomics- basics of designing a microarray, image analysis and normalization, annotations, protein prediction tools- protein secondary structure, molecular modeling, identification and characterization of protein mass fingerprint, world- wide biological databases, Introduction to programming languages such as “C”.

### Suggested Literature:

1. Latest software and articles available on University internet sites and subscribed sites.
2. Latest e-books and the text books available in the Department and University Library.
3. Bioinformatics: Sequence and Genome Analysis, Mount, D. W. (2nd Ed., 2001), Cold Spring Harbor Laboratory Press, New York, USA.

4. Principles of Biostatistics, Pagano M., Gauvreau, K, (2000), Duxbury Press, USA.
5. Bioinformatics for Dummies, Claverie J. M., Notredame C., (2nd Ed., 2007), Wiley Publishing, Inc., New York, US.

## **Computational Biology, Biostatistics and Bioinformatics Lab (ZOOL6104)**

### **Practicals**

1. Use of excel sheet for data processing.
2. Use of search engines like Scopus, Science direct for reference material collection and management.
3. Nucleic acid and protein sequence databases.
4. Data mining for sequence analysis.
5. Web– based tools for sequence searches and homology screening.
6. Primer designing for gene amplification and gene cloning.
7. Annotations: ORF finder, Use of ARTEMIS or any other suitable software.
8. Construction of phylogenetic trees for DNA and proteins.
9. Introduction to microarray technology.
10. Identification of peptide finger print by nano LC- MS/MS and database search using MASCOT and OMSSA.



## Biology of Parasitism (ZOOL6201)

### Theory

Introduction to parasitology; animal associations and host – parasite relationship; distribution of diseases and Zoonosis caused by animal parasites; morphology, life-cycle, mode of infection of *Plasmodium*, molecular biology of *Plasmodium* – drug targets, mechanism of drug resistance, vaccine strategies and proteomic approaches; morphology, life-cycle, mode of infection of *Leishmania*, molecular biology of *Leishmania* – drug targets, drug resistance and vaccine strategies.

Morphology, biology, life-cycle, mode of infection of *Entamoeba*, morphology, biology, life-cycles, mode of infection of *Giardia*; gastro-intestinal nematodes, morphology, biology, life-cycles, modes of entry of *Schistosoma*, *Wuchereria*, *Brugia*, *Ancylostoma*, *Trichinella* and *Dracanculus*; molecular biology of nematodes, vaccine strategies.

Immune response and self-defense mechanisms, immune evasion and biochemical adaptations of parasites; parasites of veterinary importance.

Parasites of insects and their significance; nematode parasites of plants, morphology, biology, lifecycle and infection of crop plants by plant parasitic nematodes, plant parasitic nematodes, host parasite interactions.

### Suggested Literature:

1. Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
2. Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwell, U. K.

## **Biology of Parasitism Lab (ZOOL6202)**

### **Practical**

1. Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, helminths and arthropods.
2. Demonstration of *in vitro* culture of *Plasmodium*, infection of mice with *Plasmodium*, chasing the process of infection by histopathology and immune reactions.
3. Culturing insect parasitic nematode, and chasing the lifecycle of the nematode on the insect host.
4. Culturing an insect parasitoid and studying their infection on an insect host.
5. Studying the infection of tomato plant by root knot nematode.

# Chronobiology (ZOOL6203)

## Theory

Milestones in clock research; Chronobiology in 21<sup>st</sup> century; Evolution of biological timing system; Clocks, genes and evolution; Adaptive functional significance of biological clocks. Studying biological clocks; Biological Rhythms - Ultradian, Tidal/Lunar, Circadian and Circannual rhythms; Temperature effects and compensation; Perception of natural zeitgeber signals; Geophysical environment - Seasons; proximate and ultimate factors.

Entrainment, masking and zeitgeber cycles; parametric and non-parametric entrainment; Entrainment models; Phase shift, Phase response curves (PRC) and phase transition curves (PTC); Organization of circadian system in multicellular animals; Concept of central and peripheral clock system; Circadian pacemaker system in invertebrates with particular reference to *Drosophila*; Circadian pacemaker system in vertebrates with particular reference to rodents; Suprachiasmatic nucleus (SCN) as the main vertebrate clock; concept of core and shell.

Diversity and complexity of the clock system; Melatonin: Input or output signal of the clock system; Molecular Biology of the circadian pacemaker system: Experiments in the generation of models for the feedback loop comprising the clock, Pre-molecular genetics era, Generic core circadian feedback loop; Molecular clockworks in *Cyanobacteria*, *Neurospora*, *Drosophila* and mammals; Cellular and molecular bases of Entrainment.

Photoreception and photo-transduction; The physiological clock and measurement of day length; Role of photic and non-photoc cues in seasonality; Reversal of roles of principal and supplementary cues; Evolution of photoperiodism: comparative studies; Circannual rhythms and seasonality; Molecular bases of seasonality; The relevance of biological clocks for human welfare - Clock function (dysfunction); Human health and diseases - Chronopharmacology, chronomedicine, chronotherapy.

### Suggested Literature:

1. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
2. Insect Clocks D.S. Saunders, C.G.H. Steel, X., afopoulou (ed.)R.D. Lewis. (3<sup>rd</sup> Ed) 2002 Baren and Noble Inc. New York, USA
3. Biological Rhythms: Vinod Kumar (ed 2002) Narosa Publishing House, Delhi/ Springer-Verlag, Germany.

## **Chronobiology Lab (ZOOL6204)**

### **Practical**

1. Assay of circadian rhythms using animal model systems.
2. Assay of circadian activity rhythms in human.
3. Ambulatory blood pressure monitoring and circadian analysis.
4. Quantifying oscillations: phase, period and amplitude.
5. Dry lab exercises on the previously recorded data.
6. Recording of body temperature ( $T_b$ ) of human.
7. Experiments demonstrating the photoperiodic clock.

### Theory

Chemical foundation of biology- concepts of pH, pKa, buffer, acidity and basicity, reaction kinetics and mechanism, affinity, equilibrium, natural products and their physiological and pharmacological importance; types of macromolecules and their general properties, proteins as mediators of all physiological and behavioural processes, proteins as inter-cellular communication signals and signal recognition mediators, chemical properties of proteins, structural organization of proteins and its importance for biological functions, separation techniques and protein science, genetic origin of protein sequences, co- and post translational modifications of proteins, protein ligand interactions.

Enzyme catalysis and allosterism, structure-function relationships in antibodies, proton pumps, ion channels and membrane receptors, structural motifs and functional domains proteins-biosynthesis, storage, secretion and circulatory half-life, protein degradation and intracellular lifespan.

Extracellular matrix proteins and proteoglycans, glycoproteins and glycobiology, super molecular assemblies involving proteins (multi- nzyme complexes), nucleic acids (chromatin) and lipids (chylomicrons).

Protein data bases, protein functions and structural domains, convergent and divergent evolution of protein structure and functions; protein engineering, protein denaturation and folding, genetic disorders affecting functional proteins, protein pathology and prions; immobilized enzymes and enzyme technology.

### Suggested Literature:

1. Proteins-Structure and Molecular Properties, Creighton T.E., Freeman Company New York, USA
2. Introduction to protein structure, Braden and Tooze, Garland Publishing, London, U K
3. Biochemistry, Voet D., AND J. G. Voet, Jon Wiley and Sons Inc., USA

**Practical**

1. Estimation of protein by the methods of Biuret, Lowry, Bradford and Eosine- a comparison.
2. Determination of N-terminal amino acid by the Sanger's reagent (FDNB).
3. Peptide mapping by 2-D electrophoresis.
4. Paper chromatographic separation of aminoacids.
5. Estimation of helix content in proteins.
6. Chemical modification of Tyrosine, Arginine and Cysteine in proteins.
7. Determination of molecular mass of proteins by SDS-PAGE.
8. Deamidation of protein in alkaline medium and measurement of released ammonia.
9. Ligand binding to protein and determination of Kd value.
10. Kinetic analysis of L-glutamate dehydrogenase activity by UV-spectrophotometer.
11. Crystallization of a protein.
12. Estimation of tryptophan content by spectrophotometry.
13. Protein Kinase action and estimation of phospho serine content.
14. Biosynthesis of protein-metabolic labeling by radiolabelled amino acid.
15. Microheterogeneity in proteins-separation of charge isoforms by ion-exchange chromatography.

## Structure and Function of Genes (ZOOL6207)

### Theory

Structure of nucleic acids- structure of nucleic acids, folding motifs, conformation flexibilities, denaturation, renaturation, kinetics of hybridization, super-coiling of DNA, packaging of DNA in the nucleus, structure of chromatin, chromatin territories. Genetic material and its evolution- structure and function relationships, evolution of genetic material, genes and genomes.

DNA replication, recombination and repair- energetics of nucleic acid polymerization, accuracy during flow of genetic information, DNA polymerases, proof-reading activity, errors and damage in the DNA, mechanism of DNA repair; genome instability; transcriptional control of gene expression- positive and negative regulations, RNA polymerases, promoters and regulatory sequences, activators and repressors of transcription, transcription initiation by RNA polymerases, regulation of transcription- factor activity, elongation and termination of transcription.

Post-transcriptional gene control and nuclear transport- types of introns and their splicing, evolution of introns, catalytic RNA, alternative splicing and proteome diversity, regulation of Pre-mRNA Processing, micro RNA and other non-coding RNAs, degradation of RNA.

Transport across the nuclear envelope and stability of RNA- structure of nuclear membrane and nuclear pore complexes, processes of nuclear import and export and their regulation, degradation of RNA. Translational machinery and translational control - energetics of amino acid polymerization, tRNAs and their modifications, aminoacyl tRNA synthetases, accuracy during aminoacylation of tRNA, regulation of initiation of translation in eukaryotes, elongation and its control, inhibitors of translations.

### Suggested Literature:

1. Molecular Biology of the Gene, Watson *et al.*, (5<sup>th</sup> Ed. 2004), Pearson Education, Delhi, INDIA
2. Genes IX, Lewin, (9<sup>TH</sup> Edition 2008), Jones and Bartlett Publishers, Boston, USA

## Structure and Function of Genes Lab (ZOOL6208)

### Practical

#### 1. Studies on structure of Gene

- a. Familiarization with sterile-handling techniques for growth of bacteria, such as sterilization, growth media, types of culture etc.
- b. Isolations of genomic DNA from bacteria and mouse/rat liver.
- c. Measurement of absorption-spectrum of DNA, RNA, and nucleotides.
- d. Studies on denaturation of DNA and determination of  $T_m$  and calculation of G:C content.
- e. Studies on stability of DNA and RNA towards alkali.

#### 2 Studies on regulation of gene-expression in bacteria

- a. Studies on growth curve of *E.coli* in synthetic medium and calculation of log-phase for metabolic experiments.
- b. Studies on induction of *lac*-operon.
- c. Studies on catabolite repression of *lac*-operon and role of cAMP.

3. Generation and selection of mutants for *lac*-operon, calculation of mutation-frequency.



## Animal Behavior (ZOOL6209)

### Theory

Introduction - definition, historical outline, patterns of behaviour, objectives of behaviour, mechanism of behaviour, asking questions. Reflexes- reflex action, types of reflexes, reflex arch, characteristics of reflexes and complex behaviour. Orientation primary and secondary orientation; kinesis – orthokinesis, klinokinesis; taxis – different kinds of taxis; sun-compass orientation, dorsal- light reaction.

Eusociality, social organization in honey bee, polyphenism and its neural control, flower recognition, displacement and translocation experiment, various type of communications, production of new queen and hive, swarming, honey bee as super organism. Fixed action pattern: mechanism, deprivation experiment, controversies. FAP- characteristics and evolutionary features. Learning and instincts: conditioning, habituation, sensitization, reasoning.

Innate releasing mechanisms: key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM, mimetic releaser, code breakers. Homeostasis and behaviour: motivational system, physiological basis of motivation, control of hunger drive in blow fly and thirst drive in goat, role of hormone, motivational conflict and decision making, displacement activity, models of motivation, measuring motivation. Hormones and pheromones influencing behaviour of animals.

Altruism – reciprocal altruism, group selection, kin selection and inclusive fitness, cooperation, alarm call. 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), infanticide, sperm competition, mate guarding, sexual selection in human, consequences of mate choice for female fitness, monogamous versus polygamous sexual conflict.

### Suggested Literature:

1. Mechanism of Animal Behaviour, Peter Marler and J. Hamilton; John Wiley & Sons, USA
2. Animal Behaviour, David McFarland, Pitman Publishing Limited, London, UK
3. Animal Behaviour, John Alcock, Sinauer Associate Inc., USA
4. Perspective on Animal Behaviour, Goodenough, McGuire and Wallace, John Wiley & Sons, USA
5. Exploring Animal Behaviour, Paul W. Sherman & John Alcock, Sinauer Associate Inc. ,Massachusetts, USA
6. An Introduction to Animal Behaviour, A. Manning and M.S Dawkins, Cambridge University Press, UK

## Animal Behavior Lab (ZOOL6210)

### Practical

1. To study the responses of woodlice to hygrostimuli.
2. To study the geotaxis behaviour of earthworm.
3. To study the orientational responses of 1<sup>st</sup> instar noctuid larvae to photo stimuli.
4. To study the median threshold concentration of sucrose solution in eliciting feeding responses of housefly.
5. To study the orientational responses of larvae to volatile and visual stimuli.
6. Courtship and mating behaviour in *Drosophila*.
7. Foraging behaviour in a (Myna bird).
8. Behavioural profiling of a primate *Macacamuletta*.
9. Territorial behaviour in stray dogs.

# Comparative Endocrine Physiology (ZOOL6211)

## Theory

Concept of endocrinology: introduction to the endocrine system, classes of hormones, modes of hormone secretion. Phylogeny of endocrine system. Endocrine control of various physiological mechanisms in nemerteans, annelids, mollusks, arthropods (Insects and crustaceans) and echinodermates.

Comparative aspects of endocrine physiology in vertebrates. Evolution of pituitary gland; Physiological actions of pituitary hormones. Urophysis and action of its hormone(s). Evolution of discrete adrenal gland; Synthesis of corticosteroid, structural diversity of glucocorticoids among vertebrates, role of glucocorticoid in gluconeogenesis; Evolution of renin-angiotensin system, hormonal control of water and electrolyte balance; Catecholamine biosynthesis, its storage and release mechanism, physiological actions of adrenal medullary hormones; Importance of adrenocortical and adrenomedullary interaction.

Evolution of thyroid gland. Thyroid hormone synthesis and its regulation, paradigms of thyroid hormone action in poikilotherms and homeotherms. A comparative account of parathyroid gland and ultimobranchial body/C cells, synthesis of parathyroid hormone, calcitonin and of vitamin D<sub>3</sub>; benthic organisms and source of vitamin D; hormonal regulation of calcium and phosphate homeostasis.

Hormonal control of feeding behaviour and gastrointestinal tract functioning including acid release, gall bladder contraction and relaxation, pancreatic enzyme secretion, and GI tract motility; Pancreatic hormones and glucose homeostasis; hormones, vitellogenesis and the evolution of viviparity.

### Suggested literature:

1. Comparative Vertebrate Endocrinology, Bentley, P. J., Cambridge University Press, UK
2. Vertebrate Endocrinology, Norris D. O., Elsevier Academic Press,
3. Hand Book of Physiology, American Physiological Society, Oxford University Press, Section 7: Multiple volumes set.
4. The Insects: Structure and Function, Chapman, F.R., The English Language Book Society (ELBS) and The English Universities Press Ltd.
5. The Principles of Insect Physiology Wigglesworth, V. B., ELBS and Chapman and Hall.

## Comparative Endocrine Physiology Lab (ZOOL6212)

### Practical

1. Dissection of retro-cerebral complex (endocrine system) in insects (e.g., cockroach/any other insect).
2. Effect of hormone mimic on the metamorphosis and other bio-characteristics of lepidopteran insect (e.g., *Spodoptera litura*).
3. Dissection of endocrine system in crustaceans (neurohaemal organ).
4. Annelids (Earthworm brain/CNS) and mollusks (Brain/Optic glands in *Octopus*).
5. Pituitary cytology: a comparative study following histology, histochemistry and immunocytochemistry.
6. Adrenalectomy in rat.
7. Effect of adrenalectomy on glycogen assay.
8. Effect of metyrapone and saline administration on adrenal cortex following light microscopy.
9. Thyroidectomy in rats.
10. Effect of thyroidectomy and thyroid hormone replacement therapy on ecdysis and testicular functions in reptiles.
11. Steroid and thyroid hormone assay by ELISA.
12. Calcium estimation following fluorometry in PTH/Calcitriol treated rats.
13. Effect of orexigenic and anorexigenic hormones on feeding behaviour of rats.
14. Induction of vitellogenesis in a seasonally breeding non-mammalian vertebrate.

## Semester IV

### Stream-1 Entomology

#### Insect Diversity, Society and Evolution (ZOOL6213)

##### Theory

Morphology: external features and their articulation. Comparative study of head-antennae, mouth parts; thorax – legs, wings; abdominal appendages, genitalia. Taxonomy- historical development of classification of insect, basis of insect classification; classification of insects up to sub orders and up to super families in economical important groups; fossil history, origin and evolution of insects

Insect Society: group of social insects and their social life; evolution of sociality; social organization and social behaviour in honey bee, ants, termites and wasps. Insect Plant Interaction - Theory of co-evolution, role of allelochemicals in host plant mediation, tritrophic interaction, host-plant selection by phytophagous insects, establishment of insect population on a plant surface. Forensic Entomology: Introduction, forensically important insects, collection of data from cadaver site, interpretation of data for predicting time and cause of death.

##### Suggested Literature:

1. A general text book of entomology, Imms , A. D., Chapman & Hall, UK
2. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, M. F., M Saunders College Publication, USA
3. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
4. The Insect Societies, Wilson, E. O., Harward Univ. Press, UK
5. Host Selection by Phytophagous insects, Bernays, E. A., and Chapman, R. F., Chapman and Hall, New York, USA
6. Insect Plant Biology, Schoonhoven, L. M., van Loop, J. A., & Dicke. M. Pub. Oxford Univ. Press. USA

## Theory

- Unit 1. Introduction:** Definition of pesticides, brief history, pesticides registration, pesticide industries and markets in world and India.
- Unit 2. Toxicology of pesticides:** LD<sub>50</sub> and LC<sub>50</sub>, Dose-response relationship; Carcinogenic, Mutagenic and Teratogenic effects, Method of testing chemicals on insect and evaluation of toxicity.
- Unit 3. Group characteristics and function of pesticides :** Organochlorines, Organophosphorus insecticides, Carbamates, Pyrethroids, other plant origin bio-insecticides, neonicotinoids and nitrogenous insecticides; fumigants; IGRs, attractants, repellents and anti-feedants. Properties of few individual insecticides i.e. DDT, HCH (BHC), Lindane, Endosulfan, Parathion, Malathion, Carbaryl, Cypermethrin, etc.
- Unit 4. Mode of action:** Central Nervous system, Acetylcholinesterase and unknown modes of action. Metabolism of insecticides: Phase I and Phase II reactions and metabolism of other pesticides.
- Unit 5. Toxicological symptoms of** Organochlorines, Organophosphorus, Carbamates, Pyrethroids, plant origin insecticides and other bio-insecticides.
- Unit 6. Safer pesticides:** Next generation molecules to be used as pesticides for plant protection and their chemistry. Nano pesticides: Use of nano-pesticides in plant protection, delivery technology and their behavior in different ecosystem. Therapy and antidotes: Type and severity of contamination and medical aid.
- Unit 7. Ecology and biodiversity of insects:** Insect biodiversity and their functioning in Terrestrial and aquatic ecosystem, Restoration of terrestrial ecosystem using the soil biota.
- Unit 8. Global environmental impact on insects:** Impact of global climatic changes on insect behavior, physiology and reproduction.
- Unit 9. Toxic chemicals and survival of insects:** Impact of Pesticides, Heavy Metals, Pharmaceuticals and other pollutants on insect physiology, their survival, reproduction and biodiversity.

### Suggested Literature:

1. Toxicology and Risk Assessment: A Comprehensive Introduction, Greim H., and Snyder, R. (ed), John Wiley and Sons, UK
2. The Complete Book of pesticide management, Whitford, F., Wiley Interscience, John Wiley and Sons, UK
3. Safer Insecticides, Hodgson, E., and Kuhr, R. J., (ed), Marcel Dekker Inc., New York, USA
4. Pesticide Application Methods, Matthews, G, A., Blackwell Science, London, UK
5. Pesticide Biochemistry and Physiology, Wilkinson, C. F., Plenum Press, New York, UK
6. Metabolic pathways of agrochemicals Part II, Roberts, T. R., and Hutson, D. H. The Royal Society of Chemistry, UK
7. Chemical Ecology of Insects, Carde, R. T., and Bell, W. J., Chapman & Hall, New York, USA

## Stream 2: FISH BIOLOGY

### Diversity and Behaviour of Fishes (ZOOL6215)

#### Theory

- Unit 1.** **Origin, Evolution and Distribution** of major groups of fishes, Evolutionary Strategies, Gene and Genome Duplication, Evolutionary Genetics, Biogeographical Distribution, Methods employed in Phylogenetic Studies and Fish Identification.
- Unit 2.** **Comparative anatomy** of skin, scales and fins, digestive system, circulatory system, respiratory system including accessory respiratory organs, urinogenital system and immune system.
- Unit 3.** **Behaviour** in relation to feeding, schooling, migration, courtship, mating and parental care. Adaptations and Symbiotic associations.
- Unit 4.** Sources of **Aquatic Pollution**, Impact of pollution on aquatic organisms, Impact of exotic fish species and GMOs on aquatic biodiversity, Fishes and their relationship with abiotic and biotic factors.

#### Suggested Literature:

1. Biology of Fishes. 2008. Bone, Q. and Moore, R., Talyor and Francis Group, CRC Press, U.K.
2. The Diversity of Fishes. 1994. G.S. Helfman, B.B. Collette & D.E. Facey (Eds) Blackwell Sceince, USA.
3. Readings in Ichthyology. 1979. M.S. Love and G.M. Cailliet (eds). Prentice-Hall of India.
4. The Senses of Fish Adaptations for the Reception of Natural Stimuli. 2004. von der Emde, R., Mogdans, J. and Kapoor, B. G., Narosa Publishing House, New Delhi, India.

## Aquatic Resources and their Conservation (ZOOL6216)

### Theory

- Unit 1. Aquatic Resources:** Riverine fisheries, Cold water fisheries, Marine fisheries, Impact of interlinking of rivers on fisheries, Biology of commercially important fishes of India (sardine, mackerel, hilsa, mahseer). Origin of lakes and lake morphology. Light, temperature, oxygen and other dissolved gases in lakes, pH and redox potential in relation to the aquatic ecosystems.
- Unit 2. Aquatic Organisms:** Distribution patterns of planktonic organisms. Phytoplankton-zooplankton relationships. Planktonic community organization in relation to predators. Adaptations of planktonic organisms to different aquatic habitats. Bio-indicators and Biomonitoring.
- Unit 3. Fishing Techniques:** Remote sensing, sonar, radar; crafts and gears. Fishways and screens.
- Unit 4. Stock Assessment and Management:** Marking, Tagging and Population enumeration, Length-weight relationship, Age and growth, Fecundity estimation, Application of statistical methods in fisheries, Fish conservation and Fishing laws.
- Unit 5. Post Harvest Technology:** Fish spoilage, rigor mortis, rancidity, enzymatic spoilage, microbial spoilage. Principles and methods of fish preservation, Problems associated with fish preservations, Processing and marketing of fish by-products.

### Suggested Literature:

1. Computers in Fisheries Research, 2009. Megrey, B. A. and Moksness, E. Springer, USA.
2. Biological Invasions in Marine Ecosystems Ecological, Management and Geographic Perspectives. 2009. Rilov, G. and Jeffrey, A. C. , Springer-Verlag, Germany.
3. Handbook of Fisheries and Aquaculture. 2013. Indian Council of Agricultural Research, ICAR, DIPA, New Delhi, India.



## Stream 3: Genomes and Evolution

### Genomics (ZOOL6217)

#### Theory

- Unit 1. Organization and structure of genomes:** size, complexity, gene-complexity, virus and bacterial genomes, organelle genome, architecture of mitochondrial genome, conserved chloroplast DNA; organization and nature of nuclear DNA in eukaryotes; transposable elements, retro-teaspoons, SINE, LINE, Alu and other repeat elements, pseudogenes, segmental duplications.
- Unit 2. Mapping genomes:** physical maps, EST, SNPs as physical markers, radiation hybrids, FISH, optical mapping, gene maps, integration of physical and genetic maps; sequencing genomes: high-throughput sequencing, strategies of sequencing, recognition of coding and non-coding regions and annotation of genes, quality of genome-sequence data, base calling and sequence accuracy.
- Unit 3. Bioinformatics:** datasets, sequence analysis based on alignment, de novo identification of genes, in silico methods. Comparative genomics- orthologs and paralogs, protein evolution by exon shuffling; human genome project, comparative genomics of bacteria, organelles, and eukaryotes.
- Unit 4. Large scale mutagenesis and interference:** genome wide gene targeting; systematic approach, random mutagenesis, insertional mutagenesis, libraries of knock-down phenocopies created by RNA interference; transcriptome analysis, DNA micro-array profiling, data processing and presentation, expression profiling, proteomics - expression analysis, protein structure analysis, protein-protein interaction.

#### Suggested Literature:

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W.H.Freeman and Company, New York, USA
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK
3. Molecular Biotechnology: Principles and application of recombinant DNA, Bernard R. and Jack, ASM Press, Herndon, USA

## Microbiome (ZOOL6218)

### Theory

- Unit 1. Microbes:** (bacteria, virus, fungi and protozoa which colonize human and animal body), Role of Microbiome in health of Human, Development of Microbiome in human from mother to old age, Role of Genome, environment and lifestyle in development of microbiome.
- Unit 2. Biodiversity and their function:** Importance of the communities of microorganisms that inhabit the human body. Human Pathogens and their mechanism of disease establishment, Microbiome and Immunity and their role in protection from pathogens, Cross-Talk Between Gut Microbiome and Host Metabolism Under Normal Physiological Condition.
- Unit 3. Human Microbiome:** Gut Microbiome and their role in digestion and nutrition, Skin and Oral Microbiome, Microbiome in other human tissues, Microbiome and Diseases, Virome in Health and Diseases, Mycome in Health and Diseases, Application of Microbiome in treatment of disease.
- Unit 4. Pioneering projects in metagenomics** - the acid mine drainage project, the Sargasso sea metagenomics survey and community profiling, the antibiotic resistor project, viral metagenomics, metagenomics of insects

### Suggested Literature:

1. The course will be taught from papers published in “Nature, Science, Cell, Microbiome, Gut” and other journals

## Stream-4: Molecular Endocrinology and Reproduction

### Neuroendocrinology (ZOOL6219)

#### Theory

- Unit 1. Introduction, History and Milestones:** General organization of central nervous system and brain in mammals, Type and structural characteristics of neurons, The information flow in the brain: connections and synapses, The transmitter systems: Amine neurotransmitters, Amino acid neurotransmitters, Peptide neurotransmitters. Principles and application of techniques used in neuroendocrinology
- Unit 2. The Hypothalamus:** Hormones from hypothalamus, Chemistry and physiology of releasing and release-inhibiting hormones, Regulation of hypothalamic secretion, Environment and hypothalamus. Development and cytology of the pituitary gland, Regulation of pituitary hormone secretions Hypothalamo – hypophyseal axis, Adenohypophysis: Regulation of the release of adenohypophyseal hormones, Neurohypophysis: synthesis and storage of oxytocin and vasopressin.
- Unit 3. The pineal gland:** Phylogeny and peculiarities of pinealocytes, Biosynthesis and regulation of melatonin secretion, Melatonin rhythms: daily and seasonal effects, Role of pineal in circadian physiology, Regulation of pineal secretion, Melatonin receptors, Physiological actions: Melatonin and neuroendocrine functions.
- Unit 4. Hypothalamus and internal timing:** Neuroendocrinology of homeostasis and temperature regulation, Neuroendocrinology of hunger and satiety in mammals, Neuroendocrinology of the stress response, Neuroendocrine integration and immune function, Neuroendocrine control of seasonal processes, Neuroendocrinology of adolescence and puberty.

#### Suggested Literature:

1. Handbook of Neuroendocrinology: George Fink, Donald W. Pfaff and Jon E. Levine

## Theory

- Unit 1. Embryo implantation:** morphological, physiological and molecular aspects of embryo-uterine interactions, implantation window, mechanism of implantation. Differentiation of cytotrophoblasts to syncytiotrophoblasts. Mechanism of placentation and placental transport function. Maternal physiology during pregnancy, Maternal adaptation to pregnancy, Fetal-placental physiology. decidualization, molecular and morphological markers of endometrial receptivity.
- Unit 2. Placental neuro-endocrine functions:** hormones of pregnancy and their mechanism of action. Prevention of menstruation during pregnancy. Parturition and its control, Lactation and its hormonal control. Inhibition of the hypothalamic gonadotropin-releasing hormone (GnRH) pulse center by suckling and prolactin, in turn suppression of the gonadotropins (luteinizing hormone [LH] and follicle-stimulating hormone [FSH]), leading to low levels of the ovarian sex steroids (estradiol and progesterone).
- Unit 3. Maternal immune-suppression during pregnancy:** Role of hormones in the regulation of immune system during pregnancy. Theories and models of immune tolerance in the context of pregnancy. Autoimmune bases of infertility and pregnancy loss.
- Unit 4. Parturition and its hormonal regulation:** Lactation, Metabolic homeostasis in human pregnancy and lactation. Nutrition and health during pregnancy and lactation, skeletal demineralization during lactation. Pathophysiological of pregnancy: Proposed mechanism of implantation failure, recurrent abortions, preeclampsia and Gestational diabetes. Developmental origins of health and diseases.

### Suggested Literature:

1. Regulation of Implantation and Establishment of Pregnancy in Mammals, Editors: Rodney D Geisert, Fuller W. Bazer, ISBN 978-3-319-15856-3, Springer International Publishing, 2015.
2. Kovac CS and Kronenberg HM, Maternal-fetal calcium and bone metabolism (Eds.) 2012. Elsevier Inc.