Distribution of Different Courses in Various Semesters (2 years PG Program in Zoology SEMESTER-I

Course Code	Theory	End	Internal	Total
		Semester	Marks	Marks
		Marks		
LZT 101	Non Chordata & Chordata	60	40	100
LZT 102	Entomology & Fish Biology	60	40	100
LZT 103	Endocrinology	60	40	100
LZT 104	Histology, Histochemistry and Biostatistics	60	40	100
LZT 105	Lab. Exercises based on courses LZT 101& 102	60	40	100
LZT 106	Lab. Exercises based on courses LZT 103 & 104	60	40	100
Total		360	240	600

SEMESTER-II

Course	Theory	End	Internal	Total
Code		Semester	Marks	Marks
		Marks		
LZT 201	Genetics, and Molecular Biology	60	40	100
LZT 202	Biochemistry and cell Biology	60	40	100
LZT 203	Mammalian Physiology	60	40	100
LZT 204	Biotechniques and Bioinformatics	60	40	100
LZL 205	Lab. Exercises based on course LZT 201 and 202	60	40	100
LZL 206	Lab. Exercises based on course LZT 203 and 204	60	40	100
Total	I	360	240	600

SEMESTER-III

Course	Theory	End	Internal	Total
Code		Semester	Marks	Marks
		Marks		
LZT 301	Developmental Biology & Immunology	60	40	100
LZT 302	Evolutionary Biology & Economic Zoology	60	40	100
LZL 303 A	Major Elective Course I			
	Mammalian Reproductive Physiology and Endocrinology			
	Paper I – Neuroendocrinology and Non-Classical Hormones.	60	40	100
	Paper II – Male and Female Reproduction	60	40	100
LZL 303B	Major Elective Course II			
	Fish Biology			
	Paper I – Fish Culture and Pathology	60	40	100
	Paper II – Fish Anatomy and Physiology	60	40	100
LZT 303C	Major Elective Course III			
	Neuroscience			
	Paper I-Cellular Neurobiology and neuron organization	60	40	100
	Paper II – Cellular neurophysiology and Neurochemistry	60	40	100
LZL 305	Lab. Exercises based on courses LZT 301 & 302	60	40	100
LZL 306	Lab. Exercises based on courses LZT 303 & 304	60	40	100
Total		360	240	600

SEMESTER-IV

Course Code	Theory	End Semester Marks	Internal Marks	Total Marks
LZT 401	Animal Behaviour & Environmental Biology	60	40	100
LZT 402 A	Major Elective Course I			
	Mammalian Reproductive Physiology and Endocrinology			
	Paper III – Hormone Receptors and Signaling Mechanisms.	60	40	100
	Paper IV – Fertility and Sterility	60	40	100
LZT 402 B	Major Elective Course II			
	Fish Biology			
	Paper III – Fish Reproduction, Genetics and			
	Biotechnology	60	40	100
	Paper IV – Capture Fishery	60	40	100
	Major Elective Course II			
LZT 402 C	Paper III – Sensory, Motor System and Regulation	60	40	100
	Paper IV – Developmental Neurobiology	60	40	100
LZL 404	Lab. Exercises based on courses LZT 402 & 403	60	40	100
LZL 405	*Project work/*Dissertation/**Seminar	120	80	200
	Total	360	240	600

Note: 1. Each student will able to opt any one out of the three special papers (a, b and c).

2. Each group will a set 4 theory paper and corresponding laboratory exercises

* The project work/disserttion will be carried out in the field of respective group (a, b and c)

****On a current topic with in the 45 minutes to be evaluated by a panel of examiner**

LZT 101: NON CHORDATA & CHORDATA

Unit 1: Protozoa: Nucleus and reproduction;Origin of metazoans; Porifera: Canal system; Cnidaria: Polymorphism in Siphonophora. Annelida: Adaptive radiation in polychaetes, Trochophore larva.

Unit 2: Mollusca: Torsion in gastropods, larval forms; Arthropoda: Evolutionary significance of Trilobites, Crustacean larvae and their significance. Echinodermata: larval forms and their significance.

Unit 3: Salient features and affinities of Placozoa, Mesozoa, Rotifera, Phoronida, Sipuncula and Hemichordata

Unit 4: Characteristic features and affinities of Protochordata and Cyclostomata; Origin of the Fish, Amphibian, Special character of amphibian : Parental care

Unit 5: Characteristic features and affinities of Reptile, Bird, Mammal, Adaptive radiations in vertebrates: Aquatic, Terrestrial, Aerial, Arboreal, Fossorial. Special characters: Venom in ophidians, Poisonous and Non-poisonous snakes; Biting mechanisms of snakes Migration in birds Flightless birds.

Books Recommended

Jordan & Verma : Chordate Zoology (1998, S.Chand)

Kotpal: The Birds (4th ed, 1999, Rastogi Publications)

McFarland *et.al* : Vertebrate Life (1979, Macmillan Publishing)

Parker & Hashwell : Textbook of Zoology, Vol.II (1978, ELBS)

Romer & Parsons : The Vertebrate Body (6th ed 1986, CBS Publishing Japan)

Sinha, Adhikari & Ganguli : Biology of Animals Vol.II (1988, New Central Book Agency)

LZT 102: ENTOMOLOGY & FISH BIOLOGY

Unit 1: Importance and taxonomic richness of insects: External anatomy: Segmentation and tagmosis; Integument: structure and functions of cuticle, sclerotization; Types of antennae and mouth parts; Sensory system: Tactile mechanoreceptor and position receptor, Compound eye, Endocrine system and function of hormones.

Unit 2: Internal anatomy and physiology: Nervous system, Circulatory system: heart and haemolymph; Respiratory system: Aerial respiration (Spiracles, Trachea and Tracheoles), Aquatic respiration; Digestive system: Structure of gut; sound production, bioluminescence

Unit 3: Excretory system and waste disposal: Malpighian tubules, nitrogen excretion. Reproductive system; Insects as friends and foes, General methods of insect pest management.

Unit 4: Integument: Epidermis (Mucogenic and Keratiniized), Epidermal derivatives: microridges, integumentary glands; Dermis: General organization; Scales: cosmoid, gnaoid, placoid, ctenoid and elasmoid; Chromatophores: melanophores, iridophores, xanthophorres and erythrophores; Factors affecting colour change; adaptive significance.

Unit 5: Ichtyology and its scope, Growth and energetics: concept of growth, determination of age and growth, correlation of growth in relation to body weight and length; role of minerals and vitamins in growth regulations, economic importance of fishes.

Books Recommended

Entomology

- 1. Chapman: The Insects: structure and function (4th ed, 1998, ELBS)
- 2. Imms: A general text book of entomology, 2 vols (1997, Asia Publishing House)
- 3. McGavin: Essential Entomology (2001, Oxford Univ Press)
- 4. Srivastava: A text book of applied entomology, Vol I & II (1993, Kalyani Publishers)
- 5. Wigglesworth: Principles of Insect Physiology (1972, ELBS)

Fish Biology

- 1. Brown: Physiology of fishes, Vols 1 and 2 (1957, Academic press)
- 2. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, S. Chand)
- 3. Hoar and Randall: Fish Physiology, Volumes I-XV (1969-onwards, Academic Press)
- 4. Khanna and Singh: A textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
- 5. Norman and Greenwood: A History of Fishes (3rd ed 1975, Ernest Bvenn Limited)
- 6. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
- 7. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
- 8. Parihar: Fish Biology and Indian fisheries (1999, Central publishing House Allahabad)

LZT 103: ENDOCRINOLOGY

Unit 1: Mechanism of hormone action: Protein hormones, Membrane receptors, G-proteins, Cyclic AMP signaling cascade, PKC signaling pathway, Steroid hormones (genomic and nongenomic pathways)

Unit 2: Hypothalamo-hypophysial System: General organization, Neurohypophysial hormones: oxytocin and vasopressin, Neural control of adenohypophysis: hypophysiotropic hormones and actions, Adenohypophysial hormones: chemistry and physiological roles of somatotropin and prolactin, Glycoprotein hormones: FSH, LH and TSH and Pro-opiomelanocortin: ACTH, MSH.

Unit 3: Thyroid hormones: biosynthesis, control of secretion and physiological role of thyroid hormones. Parathyroid: Parathormone, calcitonin and vitamin D in calcium homeostasis; Endocrine pancreas: biosynthesis and physiological actions of insulin and glucagon.

Unit 4: Gonadal hormones: Steroid hormone biosynthetic pathways, Testis: organization and physiological role of androgens, Ovary: organization and physiological role of estrogen, progesterone, relaxin and inhibin.

Unit 5: Adrenal cortex: Organization Mineralocorticoid and glucocorticoid hormone: control of secretion and physiological role. Adrenal medulla: catecholamine biosynthesis, release and physiological role.

Books Recommended

- 1. Bentley: Comparative Vertebrate Endocrinology (1998, Cambridge University Press)
- 2. Norris: Vertebrate Endocrinology (4thed 2007, Academic press)
- 3. Hadley: Endocrinology, Prentice Hall (6th ed. 2007)
- 4. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
- 5. Turner and Bagnara: General Endocrinology (1984, Saunders)
- 6. Larson: Williams Textbook of Endocrinology (10th ed 2002, Saunders)

LZT 104: HISTOLOGY, HISTOCHEMISTRY AND BIOSTATISTICS

Unit 1: Fixation and tissue processing: Types of fixatives, Chemistry of fixation, Choice of fixatives, Dehydration, Clearing and embedding. Microtomy: Types of microtome, Sectioning of paraffin blocks. Staining of paraffin sections: Principle and methods of staining, Histological stains: haematoxylin and eosin

Unit 2: Principles and methods of histochemical localization and identification of: Carbohydrate moieties: Glycogen and glycoproteins by periodic acid Schiff's method. Glycoproteins by alcian blue methods. General lipids by Sudan black B method Neutral lipids by Sudan III and Sudan IV methods; Nucleic acids: Methyl green pyronin-Y for DNA and RNA, Feulgen reaction for DNA.

Unit 3: Protein end groups: General protein localization by bromophenol blue method; $-NH_2$ groups by Ninhydrin-Schiff method. Detection of enzyme activity: Principles of enzyme histochemistry: Acid and alkaline phosphatases by metal precipitation or azo dye methods. Basic principles of immunohistochemistry and fluorescence staining

Unit 4: Measures of central tendency: Definition, Characteristics of satisfactory averages, types of averages, their merits and demerits; Measures of dispersion: Range, Mean deviation, Standard deviation, Standard error of mean,

Unit 5: Variance, Coefficient of variation, Correlation and Regression and their coefficients; Test of significance: Z-Test, Student t- test, Chi-squire test; ANOVA; Elementary idea of probability.

Books Recommended

Histology & Histochemistry

- 1 Bancroft & Stevens: Theory and Practice of Histological techniques (2002, Churchill- Livingstone)
- 2. Casselman: Histochemical techniques (1959, John Wiley)
- 3. Pearse: Histochemistry: Theoretical and Applied (Vol. I, II & III) (4th ed 1980-1993, Churchill-

Livingstone).

Biostatistics:

- 1. James L. Bruning, B. L. Kintz, Computational Handbook of Statistics (4th Edition).
- 2. Helmut Fritz Van Emden, Statistics for Terrified Biologists. WileyBlackwel (2008).
- Rebecca W Bremer, Martina . Statistics at the Bench- A Step-by-Step Handbook for Biologists (09) by Doerge, (2009).

LZL 105: LAB EXERCISES

(Based on papers LZT 101 and LZT 102)

1. Non Chordata: Preparation of permanent slides. Protozoa: *Paramecium* (whole mount) and demonstration of food vacuoles. Cnidaria: *Bougainvillea, Sertularia,* Arthropoda: Cyclops, Megalopa/Zoea, spiracles of cockroach. Mollusca: Glochidium larva, Echinodermata: Spheredium, pedicellaria, tubefeet.

2. Dissections: Arthropoda: Salivary glands of cockroach, Mollusca: nervous system of *Mytilus* and *Aplysia/Sepia*, Study of museum specimens of Porifera, Cnidaria, Annelida, Arthopoda, Mollusca, Echinodermata.

3.Chordata: Study of external features of *Branchiostoma*. Study of whole mount preparations of following protochordates. *Doliolum, Pyrosoma, Salpa* and *Oikopleura*. T.S. through pharynx, gonads and post anal region of *Branchiostoma*. T.S. and L.S. through proboscis of *Balanoglossus*.

4.Study of adaptations: Fossorial adaptation and urino-genital system of rat. Study of adaptive features of: Amphibians, Reptiles, Birds, Mammals through Chart.

Entomology

- 1. Study of external morphology of cockroach:
- 2. Internal anatomy of cockroach: Alimentary canal, Salivary apparatus: dissection and *in toto* stained preparation.
- 3. Dissection of frontal ganglion, brain, corpora cardiac (CC), corpora allata (CA) and recurrent nerve.
- 4. Dissection and mounting of prothoracic gland
- 5. Dissection of male and female reproductive systems of cockroach
- 6. Study of external morphology of honey bee and dissection of sting apparatus
- 7. Study of following using permanent slides/specimens: L.S. of teleotrophic and polytrophic ovarioles, T. S. of testis, and brain showing median neuro secretory cells (MNSC), whole mount of head of louse, CC & CA, and *Chironomous* larva.

Fish Biology

- 1. Classification of the following locally available fishes using key: Carps: *Catla catla; Labeo rohita, Cirrhina mrigala;* Catfishes: *Heteropneustes fossilis, Clarias batrachus.*.
- 2. Dissection and display of accessory respiratory organs of *Clarias batrachus, Channa sp, Heteropneustes fossilis.*
- 3. Study of larvivorous fishes through museum specimens.
- 4. Mounting of respiratory epithelium of accessory respiratory organs of *H. fossilis* and air bladder epithelium of carp.
- 5. Study of museum specimens of fishes having electric organs, venomous organs and air breathing organs.
- 6. Study of T.S. of gills, accessory respiratory organs and swim bladder from prepared slides.

LZL 106: LAB EXERCISES

(Based on papers LZT 103 and LZT 104)

1. Paraffin sectioning: Fixation of tissue (intestine and stomach of rat), dehydration, clearing and embedding of tissue. Sectioning and spreading of sections. Histological staining of paraffin sections using haematoxylin and eosin method.

2. Histochemical staining of paraffin sections for demonstration of acidic glycoproteins by Alcian Blue pH 2.5 method. Histochemical staining for lipids using: Sudan black B method, Sudan III method, Sudan IV method.

Biostatistics

- 1. Analysis of Mean, Median and Mode in given exercise.
- 2. Analysis of Standard Deviation and Standard Error in given exercise.
- 3. Analysis of Variance in given exercise.
- 4. Exercise to find out statistical significance of an experimental data using T-Test, Newmann

Keuls and Tukey's test for significance.

Endocrinology

- 1. Handling, sexing, numbering and maintenance of rat
- 2. General survey of endocrine glands in rat
- 3. Study of vaginal smear preparation in rat
- 4. Demonstration of the following surgical operations in rat: orchidectomy, ovariectomy
- Study of histological slides of the following endocrine glands in rat: pituitary, thyroid, adrenal, endocrine pancreas, testis and ovary Demonstration of endocrine glands in cockroach
- 6. Demonstration of frog metamorphosis by models and charts

SEMESTER II

LZT 201: GENETICS AND MOLECULAR BIOLOGY

Unit 1. Mendel's laws and their chromosomal basis: Extensions of Mendelism, Dominance relationships, Epistasis, Pleiotropy, Expressivity and penetrance. Methods of gene mapping: 3-point test cross in *Drosophila*, Gene mapping in human by linkage analysis in pedigrees, Tetrad analysis in *Neurospora*, Gene mapping in bacteria by conjugation, transformation and transduction.

Unit 2. Gene mutation and DNA repair: Types of gene mutations, Methods for detection of induced mutations, Pelement insertional mutagenesis in *Drosophila*, DNA damage and repair. Generation of Somatic clones and Knockouts

Unit 3. Nature of the gene and its functions: Evolution of the concept of gene, Fine structure of gene (*rII* locus), Regulation of gene activity in *lac* and *trp* operons of *E.coli* Introduction to gene regulation in eukaryotes, Organization of a typical eukaryotic gene, Transcription factors, enhancers and silencers, Transcriptional and post-transcriptional Regulation, Non-coding genes,

Unit 4. Introduction to structural and functional genomics: Chromatin organization, Nucleosomes and higher order structures, Epigenetic modifications. Post transcriptional processing and regulation: RNA editing, Post transcriptional gene silencing (RNA interference). Human genome: mapping, characteristics and implications.

Unit 5. Organization and function of mitochondrial DNA, Quantitative inheritance, Applications and implications of genetic engineering: Restriction enzymes, Cloning vectors, strategies for gene cloning; Preparation and screening of cDNA and genomic DNA libraries, Application: transgenic organisms and genetically modified organisms (GMOs), animal cloning, site-directed mutagenesis, generation of knock-out animals, Detection of genetic disorders, Gene therapy.

- 1. Lewin: Genes X (2010, Jones and Bartlett)
- 2. Brown: Genomes (3rd ed 2006, Garland Science)
- 3. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
- 4. Alberts et al: Molecular Biology of the Cell (2008, Garland)
- 5. Gardner et al: Principles of Genetics (2006, John Wiley)
- 6. Griffith et al: Modern Genetic Analysis (2008, Freeman)
- 7. Karp: Cell and Molecular Biology (2010, John Wiley & Sons)
- 8. Krebs et al: Lewin's Genes X (2011, Jones & Barlett)
- 9. Lodish et al: Molecular Cell Biology (2008, Freeman)
- 10. Pierce: Genetics A Conceptual Approach (2012, Freeman)

LZT 202: BIOCHEMISTRY & CELL BIOLOGY

Unit 1: Laws of thermodynamics and their applications: Concept of free energy and calculations based on free energy change; Protein structure; Primary structure, peptide bond, Secondary structure, α -helix, β -pleated sheet and bends, Ramachandran plot, Tertiary structure, Forces stabilizing tertiary structure, Domains and motifs-Quaternary structure

Unit 2: Enzymes: Enzyme kinetics, Lowering of activation energy, Derivation of Michaelis-Menten equation, related calculations and Michaelis-Menten and Lineweaver-Burk plots, Mechanism of action, Active site, substrate binding, transition state analogues and abzyme: Acid-base and covalent catalysis (chymotrypsin, carboxypeptidase); Concepts of regulation of enzyme activity; Metabolism: Concept of metabolic pathways; Energy transduction: glucose and fatty-acids as energy source.

Unit 3: Nucleic acids: Structure, folding motifs, conformational flexibility and supercoiling; Mechanism of DNA replication: DNA polymerases, Origin of replication and formation of primosome, Replication fork and replisome, Termination of replication; Mechanism of transcription: RNA polymerases, Formation of pre-initiation complex at RNA *pol* II promoter, Processing of hnRNA, Genetic code and mechanism of translation

Unit 4 : Cell structure and function of Viruses: structure and replication; Bacteriophage (Lambda phage, phi x 174); Animal DNA virus (SV 40); Retroviruses (HIV); Bacteria: Structure and reproduction of *E. coli*, Plasmid and their functions; Eukaryotes: cell Membrane, Lipid bi-layer and membrane proteins, Transport across the cell membrane, Channels and transporters, Diffusion, osmosis and measurement of osmotic pressure, Active transport: mechanism and related calculations.

Unit 5: Targeting and sorting of proteins: Signal peptide and SRP dependent targeting of translational complex; Processing of proteins in RER; Processing through Golgi complex: targeting to plasma membrane and lysosome; Targeting of nuclear and mitochondrial proteins; Mitochondria: Structure, assemblies of respiratory chain and F_0 F_1 -ATPase; Oxidative phosphorylation: mechanism and chemiosmotic concept, Bioenergetics of ATP and other high energy phosphate compounds; Nucleolus: structure and biogenesis of ribosomes, Cytoskeleton: organization of microtubules, microfilaments and intermediary filaments.

- 1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
- 2. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
- 3. Strayer : Biochemistry
- 4. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman and Company)
- 5. Voet and Voet: Biochemistry (2004, John Wiley)
- 6. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
- 7. Kooper : Cell biology

LZT 203: MAMMALIAN PHYSIOLOGY

Unit 1: Digestion: Role of salivary glands, liver, pancreas and intestinal glands; Digestion and absorbation of carbohydrate, fat and protein; Regulation of digestion and absorption; Digestion and absorption of macronutrients and their regulation. Nutrition, balanced diet and vitamins.

Unit 2: Circulation: Blood, Haemopoiesis, Haemostasis; Lymph: composition and dynamics; Heart: Origin and conduction of cardiac impulse, ECG and cardiac cycle, Myocardial infarction;

Unit 3: Respiration: Pulmonary ventilation; Respiratory centers: organization and function, Surfactant; Gaseous Exchange: Haemoglobin and gaseous transport, Basal metabolic rate and its measurement, Respiratory adjustments, Hypoxia and oxygen therapy, Dyspnea.

Unit 4: Excretion: Urine formation and regulation, Acid-base balance and homeostasis, Renal function tests. Muscle: Types of contraction, Muscle proteins, Mechanism and energetics of muscle contraction.

Unit 5: Nervous system: Brain structure Neurons and glia, Cerebrospinal fluid, Neural network, Blood brain barrier, Autonomic nervous system; Axonal and synaptic transmission: Types of neurons, Membrane potential and action potential, Types of synapses, Excitatory and inhibitory post-synaptic potential, Chemical transmission, neurotransmitters (acetylcholine, catecholamines, serotonin and GABA), neuropeptides.

Books Recommended

1. Ganong: Review of Medical Physiology (22nd Ed 2005, Lang Medical Publications)

2.Guyton and Hall: Text Book of Medical Physiology (11th Ed 2006, W.B. Saunders)

3. Keel et al: Samson Wright's Applied Physiology (13th Ed1989, Oxford Press)

4. Murray et al: Harper's Illustrated Biochemistry (27th Ed 1989, Appleton & Lange)

Unit 1: Centrifugation: Basic principle, Types of rotors, Clinical, high speed and ultracentrifuge. Spectrophotometry: Types of spectrophotometer, Beer-Lambert's law, molar extinction coefficient, Absorption spectrum, Principles of UV- Vis spectrophotometry. Chromatography: Principle and types, Column chromatography, Gel filtration, Ion exchange, Affinity, Introduction to FPLC and HPLC.

Unit 2: Microscopy: Basic principle, Types of microscope and their biological applications Bright-field microscope: numerical aperture, limit of resolution, types of objectives, ocular and stage micrometers, Dark-field microscope, Phase contrast microscope, Differential interference contrast microscope, Fluorescence microscope, Confocal microscope, Atomic force microscopy, Transmission and scanning electron microscope.

Unit 3: Detection of proteins, DNA-protein and protein-protein interactions: Electrophoresis: Principle, Agarose and polyacrylamide gel, Isoelectro focusing. Western blotting, DNA foot printing, EMSA, Yeast two-hybrid. Hybridization based detection of Nucleic acids: Preparation of probes, Southern, Northern hybridization; Characterization of clones: immuno-screening, Sequencing, Microarray, Radio-tracer techniques: Unit of radioactivity and half-life, Measurement of radioactivity (β and γ emission), Applications of radioisotopes, Safety measures.

Unit 4: Introduction and scope of bioinformatics: concept of digital laboratory, Basics of computers (CPU, I/O units), operating systems (Windows, UNIX), networks (LAN, WAN) and information technology, Concept of hypertext and internet protocol (HTTP, TCP/IP), Basics of home-pages, web-pages and uniform resource locators (URL), Introduction to data archiving systems (FASTA format, Accession, and GI-Number).

Unit 5: Basic features and management systems of: Nucleic acid sequences databases, Genome databases, Protein sequence, structures and interacting proteins databases, Literature databases, Biodiversity and ecosystem based databases. Introduction to data retrieval systems: Search engines, Entrez, sequence retrieval system (SRS) and protein identification resource (PIR). Introduction to molecular sequence analysis software packages and tools: Prediction of motifs, folds and domains, Sequence alignments (BLAST and Clustal W) and phylogenetic trees (PHYLIP). Applications of bioinformatics: Clinical informatics, Cheminformatic resources and pharmacoinformatics.

Books Recommended

Biochemical & Molecular Techniques

- 1. Boyer:Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
- 2. Freifelder: Physical Biochemistry (2nd ed 1982, Freeman)
- 3. Plummer: An Introduction to Practical Biochemistry (3rd ed 1990, Tata-McGraw Hill)
- Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques(6th ed 2006, Cambridge University Press)

Microscopy

- 1. Alberts et al: Molecular Biology of the Cell (2002, Garland)
- 2. Karp: Cell and Molecular Biology (2007, Wiley)
- 3. Lodish et al: Molecular Cell Biology (2007, Freeman)
- 4. Pollard & Earnshaw: Cell Biology (2002, Saunders)

5. Ruthman: Methods in Cell Research (1970, Bell & Sons)

Bioinformatics

- 1. Campbel: Discovering Genomics, Proteomics and Bioinformatics (2006, LPE)
- 2. Pevzner, P.A. Computational Molecular Biology: An Algorithmic Approach. PHI Learning, 2010.
- 3. Rastogi, Mendiratta & Rastogi. Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, 3rd Ed. PHI Learning, 2011.

LZL 205: LAB EXERCISES

(Based on papers LZT 201 and LZT 202)

Genetics:

- 1. Handling of Drosophila and study of its life cycle
- 2. Study of meiosis in grasshopper testes by squashing method
- 3. Temporary squash preparation of polytene chromosomes from salivary glands of Drosophila larvae
- 4. Study of colchicinised metaphase chromosomes in bone marrow of rodent by air dry method
- 5. Preparation of human karyotype
- 6. Study of sex chromatin in human female from buccal epithelial and hair bud cells
- 7. Examination of wild type (males and females) and mutants of Drosophila
- 8. Sex linked inheritance in Drosophila melanogaster
- 9. Linkage and crossing over in Drosophila melanogaster

Biochemistry:

- 1. Preparation of extract for enzyme assay (alkaline phosphatase)
- 2. Study of alkaline phosphatase activity
- 3. Standard curve preparation
- 4. Effect of enzyme concentration and determination of total and specific activity
- 5. Effect of temperature on enzyme activity
- 6. Effect of time on enzyme activity
- 7. Effect of substrate concentration on enzyme activity
- 8. Determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk Plot

LZL 206: LAB EXERCISES

(Based on papers LZT 203 and LZT 204)

Mammalian Physiology:

- 1. Differential leucocytes counting in blood
- 2. Determination of blood groups (ABO and Rh factor)
- 3. Estimation of ascorbic acid content in lemon extract using titration method
- 4. Preparation of casein from milk

Biotechniques

- 1. Principle and working of Centrifuges.
- 2. Principle and working of Chromatography (Paper chromatography)
- 3. Principle and working of colorimeter and spectrophotometer
- 4. Cell counting using haemocytometer (by using suitable stain)
- 5. Working and principle of Ocular micrometer
- 6. Measuring of pH using a pH meter
- 7. Electrophoresis: Nucleic acid and Protein electrophoresis.

Bioinformatics

- 1. Familiarization with computer operations and TCP/IP
- 2. Data archiving systems: FASTA format, BankIT, Accession and GI numbers
- 3. Use of search engines (Google, Altavista, Dogpile, Meta-crawler)
- 4. Demonstration of web-pages related to biological information (NCBI, ExPasy)
- 5. Hands on practice to features of following databases GenBank, PDB, DIP, PubMed, Toxnet, OMIM, Fly Base, AceDB, MGDB, HGMD, LSD, KEGG, RNAdb
- 6. Hands on practice to features of following software packages/tools: BLAST, Clustal-W, PHYLIP, M-fold

Comparative endocrinology & endocrine disorders

- 1. Preparation and study of distribution of pituitary cell types and functions (teleost model).
- 2. Study of endocrine control of colour change in amphibians with charts and models.
- 3. Study of Comparative anatomy of thyroid gland from pre-stained slides.
- 4. Study of Comparative anatomy of adrenocortical and medullary homologues.
- 5. Bioassay of Pituitary gonadotropins.
- 6. Study of endocrine disorders by charts and models.

SEMESTER III

LZT 301: DEVELOPMENTAL BIOLOGY AND IMMUNOLOGY

Unit 1: Fertilization: Fertilization in Sea urchin and mammals, Acrosomal reaction and gamete interaction. Prevention of polyspermy and egg activation Early development: Cleavage, Formation of blastula, fate maps, Gastrulation: cell movement and formation of germ layers, General concept of potency, commitment, specification, induction, competence and determination,

Unit 2: Differentiation and pattern formation, Stalk and fruiting body formation in *Dictyostellium*, Origin of anterior-posterior and dorsal-ventral polarity in *Drosophila*: role of maternal, segmentation and homeotic genes; HOX gene in vertebrates, Axis formation in frog (Nieuwkoop Centre and primary Organizer), chick and mammals.

Unit 3: Late embryonic development: Vulva formation in *Caenorhabditis*. Formation of neural tube in vertebrates. Development of limb in vertebrates: role of HOX and other pattern forming genes. Regeneration of Salamander limbs: Polar coordinate model; Stem cells and differentiation.

Unit 4: The Immune system: Innate and adaptive immunity, Immune cells: types and production, Immune tolerance, Humoral immunity: Antigen and hapten, Primary and secondary response, Immunoglobulins: types, structure and functions, Generation of antibody diversity, Class switching, somatic hypermutation, Concept of clonal selection.

Unit 5: Cell mediated immunity: T cell receptor, Major Histocompatibility Complex (MHC), Complement system; Antigen: processing and presentation, T helper cell and lymphocyte activation, Role of cytotoxic T cell, perforin and granzymes; Concept of Vaccination, Regulation of immune responses and Hypersensitivity, Autoimmunity.

Books Recommended

Developmental Biology

- 1. Alberts et al: Molecular Biology of the Cell (5th ed 2008, Garland)
- 2. Balinsky: An introduction to Embryology (5th ed 1981, Saunders)
- 3. Gilbert: Developmental Biology (8th ed 2006, Sinauers)
- 4. Kalthoff: Analysis of Biological development (1996, McGraw)
- 5. Wolpert: Principles of Development (3rd ed 2007, Oxford)

Immunology

- 1. Abbas et al: Cellular and Molecular Immunology, 6th ed, 2000, Saunders.
- 2. Albert et al; Molecular Biology of the Cell, 4th ed, 2002, Garland.
- 3. Acharya et al.: Immunology, 2nd ed. 2011, Kalyani.
- 4. Elgert: Understanding the Immune System, 1996, Wiley.
- 5. Kenneth et al: Janeway Immunobiology, 7th ed, 2009, Garland.
- 6. Kuby: Immunology, 7th ed, 2007, Freeman.
- 7. Roitt: Essential Immunology, 10th ed, 2006, Mosby.

Unit 1: An overview of evolutionary thoughts, development and the concept of synthetic theory.

Population genetics: Gene frequencies in Mendelian population, Hardy-Weinberg equilibrium Conditions for the maintenance of genetic equilibrium. Elemental forces of evolution: Mutation, Selection (types of selection and selection coefficient), Random genetic drift, Migration.

Unit 2: Chromosomal, allozyme and DNA polymorphisms: Adaptive genetic polymorphism, Balanced polymorphism and heterosis, Genetic coadaptation and linkage disequilibrium. Isolating mechanisms: Concepts of species and models of speciation: allopatric, sympatric and stasipatric,

Unit 3: Evolution at molecular level: Genomic and proteomic changes, Molecular phylogenies, Neutral theory, Molecular clock.

Unit 4: Beneficial and harmful insects, including insect vectors of human diseases. Pests of sugar cane (Pyrilla perpusilla), oil seed (Achaea janata) and rice (Sitophilus oryzae). Insects in forensic investigations; Industrial fish, prawn and molluscs of India. Apiculture, sericulture, lac culture, carp culture, pearl culture, prawn culture.

Unit 5: Major infectious and communicable diseases (small pox, plague, malaria, tuberculosis, cholera and AIDS) their vectors, pathogens and prevention. Cattle and livestock diseases, their pathogens (helminths) and vectors (ticks, mites, Tabanus, Stomoxys).

Books Recommended

Evolution

- 1. P A Moody: Introduction to Evolution
- 2. Rastogi: Organic Evolution (2007, Kedarnath & Ramnath)
- 3. Strickberger's Evolution
- 4. Verma and Agrawal, Ecology 2000, S Chand
- 5. Kormondy, E.J. Concepts of Ecology, 4th Ed. PHI Learning, 2011.

Economic Zoology:

- 1. Shukla and Upadhyaya : Economic Zoology (Rastogi Publishers, 1999-2000)
- 2. Shrivastava: Test book of Applied Entomology, Vol. I &II (Kalyani Publishers, 1991)
- 3. Mani: Insects, NBT, India, 2006.
- 4. Jabde: Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture,
- 5. Agricultural Pests and their control, 2005 Discovery Publishing House.

LZT 303 (A): MAMMALIAN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY

Paper I: Neuroendocrinology and Non-classical Hormones

Unit 1: Neuroendocrinology- Hypophysiotropic hormones: localization, secretion and mechanism of action, TRH , GnRH, CRH, GHRH and PACAP, Somatostatin, Monoamines

Unit 2: Adenohypophysis -Role of transcription factors in pituitary differentiation, Paracrine/autocrine secretions, Neural control of ACTH, TSH, prolactin and growth hormone

Unit 3: Pineal gland- Pineal, biological clock and calendar, Melatonin and photoperiodic measuremen

Unit 4: Non - classical hormones - Growth factors: cellular origin, secretion and functions, Epidermal growth factor family (EGF and TGF α), Transforming growth factor β family (TGF β , anti-Mullerian hormone,inhibins and activins) Platelet-derived growth factor family, Fibroblast growth factor family, Insulin family (IGF-1 and IGF-II), Nerve growth factor family

Unit 5: Hematopoietic growth factors (erythropoietin, thrombopoietin and colony stimulating factor), Immunoinflammatory hormones (interleukines, $TNF\alpha$ and $TNF\beta$), Eicosanoids (prostaglandins, thromboxanes and leukotrines), Leptin.

Books Recommended

1. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)

2. DeGroot and Jameson: Endocrinology (5th ed 2006, Vol 1, Elsevier-Saunders)

3. Larson. Williams Textbook of Endocrinology (10th ed 2002, Saunders Norman and Litwack. Hormones(2nd ed 1997, Academic press)

5. Henson and Castracane: Leptin and Reproduction (2003, Plenum, Publishers)

Neuroendocrinology and Non-classical Hormones

1. Norris and Lopez: Vertebrate Endocrinology (5thed, Vol 5, 2011, Academic press)

2. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)

3. Bolander: Molecular Endocrinology (3rded 2006, Elsevier)

- 4. DeGroot and Jameson: Endocrinology (5thed 2006, Vol 1, Elsevier-Saunders)
- 5. Larson. Williams Textbook of Endocrinology (10thed 2002, Saunders

6. Norman and Litwack. Hormones (2nded 1997, Academic press)

7. Henson and Castracane: Leptin and Reproduction (2003, Plenum Publisher).

LZT 303 (A): MAMMALIAN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY

Paper II: Male and Female Reproduction

Unit 1: Reproductive cycles- Menstrual cycle- Control of seasonal reproductive cycle Photoperiod and temperature, Food supply, Hormonal control of puberty and pregnancy

Unit 2: Gonadotropins- structure, secretion and regulation Sexual differentiation and behavior, Gonadal differentiation, Brain differentiation, Copulatory patterns, Hormones in sexual behavior, Sites of action of sex hormones

Unit 3: Testis- Spermatogenesis and hormonal regulation, Sertoli cell, Leydig cell, Cell – cell interactions Epididymis: organization and function, Male accessory sex glands, Structural organization and endocrine regulation of prostate, Functions of accessory sex glands

Unit 4: Regulation of ovarian function, Follicular development and selection, Oocyte maturation, Mechanism of ovulation, Hormonal and molecular changes during periovulatory period, Factors involved in follicular rupture, Follicular atresia, Regulation of steroidogenesis,

Unit 5: Fertilization and Implantation -Hormonal control of gamete interaction, Role of zona proteins, Gamete activation, Sperm-egg fusion; Biology of implantation- Cellular aspects, Molecular aspects, Markers of developing embryo, Cross-talk between embryo and uterus

Books Recommended

Male Reproduction

- 1. Adashi et al: Reproductive Endocrinology, Surgery and Technology (1996, Lippincott-Raven publishers)
- 2. Knobil& Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)
- 3. Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.
- 4. Lamming: Marshall's Physiology of Reproduction (1984, Longman)
- 5. Mann &Lutwak-Mann: The Male Reproductive Function and Semen (1998, Springer)
- 6. Paulson et al: Andrology: Male Fertility and Sterility (1986, Academic Press)
- 7. Setchell: The Mammalian Testis (1992, Cornell University Press)
- 8. Yen et al: Reproductive Endocrinology (1999, Saunders)

LZT 303 (B): FISH BIOLOGY

Paper I: Fish Culture and Pathology

Unit 1: Fish culture systems: Ponds, Fish farm: Lay out and construction of different types of ponds, Formulation and operation of different types of hatcheries, Hatchery management and hatchery breeding, Brood pond management for cultivable indigenous and exotic carps. Fish culture in paddy fields, Sewage-fed fisheries, Larvivorous fishes, Weed fishes, Hill stream adaptations in fishes.

Unit 2: Pond management: Physico-chemical properties of pond water and soil and their maintenance, Manuring (organic and inorganic) and liming, Composite fish farming and polyculture, Predatory and weed fishes and their eradication, Other systems: cage, raft, pens, raceways.

Unit 3: Chemical composition and nutritional value of fish, Fish by-products: Production and utilization: Liver oils, Fish meal, Fish silage, Fish protein, Shark fins and fin rays, Fish roes, Isinglass, Fish skin, Pearl essence.

Unit 4: Fish pathology, prophylaxis and therapy: Protozoan diseases: Cyclochaetiasis, Costiasis,

(sliminess of skin), Helminth parasites: Gyrodactylus, Dactylogyrus,

Unit 5: Crustacean parasites: *Ergasilus*, Fungal diseases: branchiomycosis (gill rot), Bacterial diseases: tail and fin rot, furunculosis, Viral diseases: papillomatosis (cauliflower disease), Nutritional diseases: avitaminoses.

- 1. Bentley: Comparative Vertebrate Endocrinology (2000, Cambridge University Press)
- 2. Gorbman et al: Comparative Endocrinology (1978, John Wiley)
- 3. Hadley: Endocrinology Prentice Hall (2011, International Editions)
- 4. Norris: Vertebrate Endocrinology (2nd ed 2009, Academic Press)
- 5. Bond: Biology of Fishes (1979, Saunders)
- 6. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)
- 7. Evans: The Physiology of Fishes(2006, CRC Press)
- 8. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
- 9. Hoar & Randall: Fish Physiology, Series Vol. I XIV (Academic Press)

LZT 303 (B): FISH BIOLOGY

Paper II: Fish Anatomy and Physiology

Unit 1: Integument: Epidermis: general organization, Dermis: general organization of scaly and non-scaly fishes. Aquatic respiration: Gills, Mechanisms of respiration, Counter current principle, Water flow across the gills, Respiratory pump, Gas exchange, Transport of respiratory gases.

Unit 2: Nervous system: Brain and cranial nerves, Receptors, Eye: structure, photoreception, formation of image, functional adaptations, Acoustico-lateralis system: labyrinth, lateral line organs, Chemoreceptors: gustatory, olfactory, electroreceptors.

Unit 3: Digestion: Alimentary canal and its modifications in relation to food and feeding habits,

Digestion and absorption of lipid, protein and carbohydrate. Gastrointestinal motility control. Excretion and osmoregulation: Glomerular and aglomerular kidneys, Excretion of nitrogenous wastes, water and ion balance, Stenohaline teleosts, Euryhaline teleosts, Migratory teleosts.

Unit 4: Circulation: General organization and circulation, Composition of swim bladder gas, its secretion, maintenance and removal, Functions of swim bladder. Heart and aortic arches, Regulation of cardiac activity, Hemodynamics, Cardiac output, Circulation time, Blood pressure, Fish hemoglobin.

Unit 5: Fish Endocrinology: Hypothalamo-hypophyseal system: neurosecretory system and hypophyseal hormones, Functional morphology of pituitary, Hypothalamic control of pituitary,

Structure and function of the following: Thyroid, Ultimobranchials, Pancreas, Adrenal,

Corpuscles of Stannius, Urophysis and Pineal.

- 1. Hughes: Comparative Physiology of Vertebrate Respiration, Heinemann Educational (1967, Books)
- 2. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
- 3. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)
- 4. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
- 5. Singh: Advances in Fish Research, Vol. I and II (1993 and 1997, Narendra Publishing House)
- 6. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)

LZT 303 (C): NEUROSCIENCE

Paper I: CELLULAR NEUROBIOLOGY AND NEURON ORGANIZATION

Unit 1: An overview of the nervous system; **Neurons**: Introduction to neurons, The Neuron Doctrine, The Nissl and Golgi stains, Components of neurons, Classification and types of neurons, Cytology of neurons, Dendrites structure and function, Axons structure and functional aspects, ultrastructure, myelination and synapses.

Unit 2: Glial cells: Structure and function of glial cells, Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells, Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, Importance of astrocytes in glutamate metabolism and blood brain barrier, Function of other glial cells: oligodendrocyte and microglial cells, Microglial phenotypes, Overview of glial and neuronal relationship in the CNS, Glial -neuronal interplay in the CNS.

Unit 3: Gross anatomy of the adult brain; organization of the nervous system; Subdivisions of the nervous system; Concept of CNS, ANS & PNS; The scalp, skull and meninges; Cerebrospinal fluid.

Unit 4: Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of: Cerebellum: Gross anatomy, cerebellar cortex, central nuclei, cerebellar peduncles; Functional anatomy of cerebellum; Cerebral cortex: Histology, general organization, functional localization; Descending motor pathways; Thalamus: Scheme of thalamic organization, nuclei of the thalamus; Basal ganglia: Corpus striatum, subthalamic nucleus, substantia nigra; Ascending sensory pathways.

Unit 5: Neuronal elements, basic circuit, synaptic action, dendritic properties and functional operation of: Auditory system; Visual system; Olfactory and Limbic system; Autonomic system.

- 1. Siegel, Basic Neurochemistry (7th Edition) Academic Press, 2006
- 2. Albertes, Molecular Biology of the Cell (5th Edition) Garland Science, 2008
- 3. Kendel, Principles of Neural Science (4th edition), McGraw Hill, 2000
- 4. Verkhratsky, Glial Neurobiology, A Text Book, Wiley, 2007

LZT 303 (C): NEUROSCIENCE

Paper II: CELLULAR NEUROPHYSIOLOGY AND NEUROCHEMISTRY

Unit 1: Electrical properties of excitable membranes: Basic electricity and electric circuits, neurons as conductors of electricity, equivalent circuit representation; Electrical properties of excitable membranes: movement of ions across biological membranes; Membrane potential and role of sodium and potassium pumps; Action potential, non-gated ion channels and generation of action potential; Electrical properties of neurons, Voltage gated channels; Biophysical, biochemical and molecular properties of voltage gated channels.

Unit 2: Synaptic vesicles Principles of synaptic transmission: Electrical and chemical synapses; Calcium hypothesis: Control of transmitter release; Synthesis and trafficking of neuronal proteins, Synaptic transmission at nerve-muscle synapses; Synaptic transmission at central synapses; Ligand gated channels; Second messengers and synaptic transmission.

Unit 3: Acetylcholine: Chemistry, synthesis, storage and release; Nicotinic and muscarinic receptors; Catecholamine: Biosynthesis, storage and release; Dopamine, adrenergic receptors

Unit 4: Serotonin: Synthesis, action and distribution; Role of serotonin receptors in behavior; Excitatory amino acid transmitters: Synthesis, metabolism, distribution and receptor subtypes; Histamine: Dynamics, molecular sites and action in the CNS; GABA, glycine: Synthesis, uptake and release; Receptors of GABA and glycine.

Unit 5: Neuropeptides neurotransmitters: Biosynthesis, function regulation and receptors; Opioid peptide and opioid receptors: Synthesis, metabolism, distribution and receptor subtypes; CSF; Micro circulation and blood brain and CSF barriers.

Books Recommended

- 1. Squire, Fundamental Neuroscience (3rd Edition), Elsevier, 2008
- 2. Kendel, Principles of Neural Science (4th edition), McGraw Hill, 2000
- 3. Mishra, Clinical Neurophysiology (2nd Edition), Elsevier, 2006
- 4. Duchene E. Haines, Fundamental Neuroscience for Basic & Clinical Applications (3rd Edition),

Churchill Livingstone, 2006

- 5. Bear, Neuroscience-Exploring the Brain, Lippincott, 2007
- 6. Siegel, Basic Neurochemistry (7th Edition) Academic Press, 2006

LZL 304: LAB EXERCISE

Lab exercises based on papers LZT 301 & LZT 302

Developmental Biology

- 1. Study of frog embryonic development through models
- 2. Collection of frog spawns and observation of different developmental stages
- 3. Study of spiral cleavage in eggs of snail
- 4. Effect of vitamin A in tadpole tail regeneration
- 5. Study of embryonic development in chick through slides
- 6. Window preparation to study chick embryo development
- 7. Whole mount preparation of chick embryos at various stages of development
- 8. Study of expression of developmental genes in larval imaginal discs.

Immunology

- 1. Separation of macrophages from mice and their identification on the basis of non-specific esterase staining
- 2. Immunization of rabbit and collection of antisera
- 3. Demonstration of antigen-antibody reaction by immunodiffusion
- 4. Demonstration of direct ELISA

Evolutionary Biology

- 1. Study of quantitative inheritance in *Drosophila*: sternopleural bristle phenotypes in *D. melanogaster*
- 2. Demonstration of natural selection under laboratory conditions by making competition between red eyed and white eyed *D. melanogaster*
- 3. Demonstration of Hardy-Weinberg equilibrium in human populations by taking examples of MN and ABO blood group systems
- 4. Study of inversion polymorphism in Drosophila
- 5. Study of sexual isolation between two closely related and sympatric species of *Drosophila*: *D. bipectinata and D. malerkotliana*.

Economic Zoology

- 1. Study of life cycle of silkworm through chart/specimens
- 2. Study of life cycle of honey bee through chart/specimens
- 3. Study of external morphology of different castes of honey bee
- 4. Dissection of sting apparatus of honey bee
- 5. Study of life cycle of lac insect through chart.
- 6. Visit to the local dairy farm to study the pests of cattle
- 7. Visit to the local dairy farm to study the dairy management
- 8. Visit to local poultry to study the rearing methods
- 9. Visit to local fish culture site to study the fish culture methods

MAJOR ELECTIVE LABORATORY EXERCISES

LZL 305 (A): MAMMALIAN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY

Neuroendocrinology and Non-classical Hormones

- 1. Study of pituitary and pineal cell types through prepared slides
- 2. In situ study of pituitary gland for portal circulation
- 3. Transplantation of pituitary in kidney capsule
- 4. *In situ* study of pineal gland and associated epithalamic complex
- 5. Anatomical mapping of hypothalamic centres (SON, PVN, AR, VMO, mammillary nucleus, median eminence)
- 6. Ascorbic acid depletion bioassay for LH
- 7. ELISA/RIA of TSH or gonadotropins

Male Reproduction

- 1. Preparation and study of permanent slides of reproductive organs: testis, epididymis (caput, corpus, and cauda), seminal vesicle and prostate
- 2. Study of stages of spermatogenesis and spermiogenesis using histological slides of testis
- 3. Biochemical estimation of fructose and alkaline and acid phosphatases in seminal vesicle and prostate
- 4. Androgen bioassay by sialic acid assay
- 5. Biochemical estimation of 3β -hydroxysteroiddehydogenase
- 6. Operations in rat: induction of cryptorchidism; vasectomy
- 7. Study of sperm motility, sperm morphology, and sperm count in rat
- 8. Effect of cadmium chloride treatment on testis

Female Reproduction

- 1. Studies on permanent slides of female reproductive organs (ovary, uterus, oviduct and vagina)
- 2. Tubectomy and hysterectomy
- 3. Induction of superovulation in mouse/rat
- 4. Induction of PCOS condition in rat
- 5. Biochemical estimation of succinate dehydrogenase and catalase activity
- 6. Study of rat oestrous cycle using vaginal smear preparations
- 7. Isolation of large antral follicle and corpus luteum
- 8. Isolation of egg, granulosa and theca cells
- 9. Demonstration of implantation sites by pontamine blue (blue dye reaction) in mouse
- 10. Demonstration of SDS-PAGE for ovarian proteins

MAJOR ELECTIVE LABORATORY EXERCISES

LZL 305 (B) : FISH BIOLOGY

Fish Physiology and anatomy

- 1. Dissection and display of afferent and efferent branchial vessels of a carp and a catfish
- 2. Study of available histological slides of: gills, accessory respiratory organs, skin. Kidneys, liver and digestive organs of a teleostean fish
- 3. Determination and comparison of hemoglobin content of water-breathing and air breathing fish
- 4. Study of ventilation rate and surfacing activity of a air-breathing fish under different experimental conditions.
- 5. Determination of feeding habit of important edible fishes by morphological analyses of their buccopharyngeal region
- 6. Determination of feeding habit of carps and catfishes by analyses of their gut contents
- Dissection of carp showing interrelationship between the gas (swim or air) bladder and Weberian ossicles.

SEMESTER IV

LZT 401: ANIMAL BEHAVIOUR AND ENVIRONMENTAL BIOLOGY

Unit 1: Introduction to behaviour: proximate and ultimate causation, Patterns of behavior, Genetic basis of behavior: Development of bird song.

Unit 2: Biological rhythms, Habitat selection and foraging behavior, Animal signals and communication, Social dominance and concept of territoriality. Sexual selection, Social organization: Theories of social behavior, Altruism in eusocial animals.

Unit 3: Introduction to environmental biology: Concept of ecosystems, Energy flow in Ecosystem. Energy and environment: conventional and non-conventional energy sources.

Unit 4: Population ecology: Population dynamics, Population growth form, r- and k- selections and carrying capacity, Biological communities and species interactions, Types of interactions between two species, Interspecific competition

Unit 5: Human impact on the environment and sustainable development: Concept of sustainable development, Environmental degradation (habitat destruction, fragmentation, biological invasions) and management, Forest, water & mineral resources, Biodiversity conservation and concept of ecosystem services, Global environmental changes (ozone depletion, acid deposition, green house gas emissions and global warming), Environmental impact assessment.

Books Recommended

Animal Behaviour

- 1. Alcock: Animal Behaviour: An Evolutionary Approach (9th ed 2009, Sinauer Asso.)
- 2. M P Kaushik: Animal Behaviour, Kalyani Publication
- 3. Shukla G, <u>Upadhyay V</u>, <u>Mathur R</u>. Economic Zoology Biostatistics & Animal Behaviour (2011, Rastogi Publication).
- 4. Mathur Reena: Animal Behaviour (Rastogi Publications, December 1, 2005) *Environmental Biology*
- 1. Primack: A Primer of Conservation Biology (4th Ed., Sinauer Associ, 2008).
- 2. Raven, Berg, Johnson: Environment. Harcourt College Pub; 2nd edition 1997
- 3. Turk and Turk: Environmental Science (4th Ed., Atlantic Books; 1988)
- 4. Wright and Nebel: Environmental Science (8th Ed., Prentice Hall, 2002).
- 5. Rastogi: Organic Evolution (2007, Kedarnath & Ramnath)
- 6. Das, M.C. Fundamental of Ecology- Tata Mcgraw Hill Publication 2001
- 7. Verma and Agrawal, Ecology 2000, S Chand

LZT 402 (A): MAMMALIAN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY

Paper III: Hormone Receptors, and Signaling Mechanisms

Unit 1: Control of hormone secretion- Synthesis, processing, and sorting of preprohormone Precursor, Sequential stages of the regulated secretory pathway, Dense-cored granule Exocytosis, Regulation of exocytosis by calcium and protein kinase C

Unit 2: Receptors - Nuclear receptors, Structure, Families (glucocorticoid, thyroid and estrogen), Metabolism, Activation and recycling

Unit 3: Membrane receptors, Enzyme-linked receptors, Cytokine receptors, G-Protein coupled receptors, Ligandgated ion channels

Unit 4: Hormone signaling- Receptor tyrosine kinase pathway, Cytokine receptors pathway, Cyclic AMP pathway, Phospholipid/calcium- protein kinase C pathway, Nitric oxide signaling pathway, MAP kinase pathway, Hormonal control of gene expression

Unit 5: Molecular basis of hormone synergism and antagonism, Glycogen metabolism Smooth muscle contraction, Termination of hormone action Pathophysiology of hormone receptors, hormone analogues as drug and xeno-estrogens

- 1. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)
- 2. DeGroot and Jameson: Endocrinology, Vol 1 (5th ed 2006 Saunders)
- 3. Larson: Williams Textbook of Endocrinology, (10th ed 2002, Saunders)
- 4. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
- 5. Squires: Applied Animal Endocrinology (2003, CABI publications)

LZT 402 (A): MAMMALIAN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY

Paper IV: Fertility and Sterility

Unit 1: Control of male fertility-Chemical interference, Suppression of spermatogenesis, Suppression of hypophysial activity by steroid hormones, Chemicals acting directly on the testis, Prevention of sperm maturation in epididymis, Immunological interference, Surgical interference with reference to vasectomy

Unit 2: Control of female fertility-Inhibition of ovulation with reference to oral contraceptives, Mechanical methods with reference to intrauterine devices, Immunological approaches

Unit 3: Male sterility - Parameters of male sterility, Origin and cause of male sterility, Azoospermia, Oligozoospermia, Varicocoele, Cryptorchidism

Unit 4: Female sterility-Tubal factors, Premature ovarian failure, Polycystic ovarian syndrome, Luteal insufficiency, Endometriosis

Unit 5: Primer pheromones- Estrous cycle disruption,Male induction of estrus (Whitten effect), Male induced pregnancy block (Bruce effect), Pheromones and puberty, Human reproductive pheromones

Books Recommended

Female Reproduction

- 1. Leung and Adashi: The Ovary (2004, Raven Press)
- 2. Adashi et al: Reproductive Endocrinology, Surgery and Technology (1996, Lippincott- Raven publishers)
- 3. Findlay: Molecular Biology of the Female Reproductive System (1994, Academic Press)
- 4. Knobil& Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)
- 5. Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.
- 6. Lamming: Marshall's Physiology of Reproduction (1984, Longman)

LZT 402 (B): FISH BIOLOGY

Paper III: Fish Reproduction, Genetics and Biotechnology

Unit 1: Functional morphology of teleostean gonad: Gametogenesis, Role of environmental factors (photoperiod, temperature, rainfall, salinity) on gonadal maturation. Gonadal steroidogenesis and its control.

Unit 2: Role of hypothalamo-hypophyseal hormones in reproduction; Types and modes of reproduction, Secondary sexual characters, Sexuality: intersex, bisexuality, hermaphroditism, Parental care: oviparity and viviparity.

Unit 3: Induced breeding: Factors responsible for induced breeding, Hypophysation, Use of different synthetic and natural hormones, their formulation and mechanism of action, Bundh breeding, Hapa breeding, Hatchery breeding, Multiple breeding of carps.

Unit 4: *In vitro* fertilization and incubation: Fish seed collection, transport of brood fishes and fish seed. Fundamentals of fish genetics.

Unit 5: Fish biotechnology: Gynogenesis, Androgenesis, Polyploidy and Sterility, Production of monosex population, Hybridization, Cryo-preservation of gametes and embryo, Transgenic fish.

Books Recommended

- 1. Evans: The Physiology of Fishes (2006, CRC Press)
- 2. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries

Division Indian Council of Agricultural Research)

- 3. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
- 4. Hoar & Randall: Fish Physiology, Series Vol. I XIV (1979-2006, Academic Press)
- 5. Howard & Churchill Canning technology (2003, London)
- 6. Huet: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News (1989)

LZT 402 (B): FISH BIOLOGY

Paper IV: Capture Fishery

Unit 1: Fishery resources of India: Inland fisheries, Riverine fishery: regulation and exploitation, river pollution, dams and their effect on fish migration, Lacusterine fishery: management, development and exploitation, Marine fishery: management, development and exploitation, Estuarine Fishery: management, development and exploitation

Unit 2: Inland fishing gears and fishing methods: Types of fishing gears, Preparation and maintenance of fishing nets. Modern techniques and equipment for finding and capturing fishes.

Unit 3: Fish Nutrition: Physiological roles of nutrients, Food and feeding habits of freshwater fishes, Nutrient requirement (proteins, lipids, carbohydrates, minerals and vitamins) for various growth stages of freshwater carps. Nutritional bio-energetics, Anti-nutritional factors and their removal, Supplementary feed, Types, Formulation and processing, storage and quality control.

Unit 4: Fish by-products: production and utilization: Liver oils, Fish meal, Fish silage, Fish protein, Shark fins and fin rays, Fish roes, Isinglass, Fish skin, Pearl essence.

Unit 5: Fish spoilage and preservation: Bacterial, Chemical and Enzymatic spoilage Drying, Salting, Smoking, Canning. Additives: classes of additives, preservatives and antimicrobial additives.

Unit 6: Age and growth: Growth rate and aging, Length weight relationship.

Books Recommended

- 1. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)
- 2. Chakroff: Freshwater Fish Pond Culture and Management (1987, Scientific Publishers)
- 3. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)
- 4. Duijn: Diseases of Fishes (1967, London Iliffe Books)
- 5. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
- 6. Khanna and Singh: Textbook of Fish Biology and Fisheries (Narendra Publishing House) 2003
- 7. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)
- 8. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
- 9. Ribelin & Migaki: The Pathology of Fishes (1975, The Univ. of Wisconsin Press)
- 10. Santhanam: Fisheries Science (1990, Daya Publishing House)
- 11. Srivastava, Gopalji: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
- 14 .Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) S Chand 2006.

LZT 402 (C): NEUROSCIENCE

Paper III: SENSORY, MOTOR SYSTEMS AND REGULATORY SYSTEM

Unit 1: Transduction and processing of sensory signals-Basic Principles: Sensation and perception, Receptors, Parallel processing, Central processing, Common anatomical plan, Structure, function & connections of sensory cortex Sensory Transduction: Phototransduction, olfactory transduction, taste, mechanoreception Somatic sensation: Peripheral mechanisms of somatic sensation, Spinal and Brainstem components of somatosensory system, Thalamic ventrobasal complex.

Unit 2: Primary somato-sensory cortex and information processing on touch, representation of body surfaces in the brain, cortical responses to stimuli. Pain: Nociceptors, hyperalgesia, control of pain, opioid peptides and pain Taste: Taste receptors and taste buds, turnover & replacement, Innervation by cranial nerves, Flow of gustatory

afferent information, Extraction of sensory information, Turning of peripheral taste fibers, Gustatory neuron types, Modulation of taste activity in the Medulla.

Unit 3: Fundamentals of Motor Systems: Spinal cord as central pattern generator; Reflexes and locomotion, Brain projections to spinal cord ;Voluntary Descending Control: Cortical pathways to Motor Neurons, Organization of the Motor cortex,: Anatomy of the Basal Ganglia, Signaling in Basal Ganglia, Effect of damage in behaviour, Fundamental Principles of Basal Ganglia operation Cerebellum.

Unit 4: Chemical Control of Brain and Behaviour: Organizational Principles of the Adult Hypothalamus Role of hypothalamus and pituitary hormones The ANS in regulation of brain and bahaviour ANS Pharmacology-Transmitter and Receptor Coding, Autonomic Controls of Homeostasis, Hierarchically Organized CNS Circuits.

Unit 5: Cardiovascular System: Basics of Cardiovascular physiology, Sympathetic Vasomotor Tone, Neural Control of Heart, Cardiovascular Homeostasis; . Neural Control of the Breathing: Early Neuroscience and the Brainstem, Breathing & gas exchange, CNS & Breathing, Respiratory Rhythm Generation Sensory Inputs and Altered Breathing, Modulation of Respiratory Motor Out-put; Circadian Timing: Pineal and Circadian Rhythms, The Suprachiasmatic Nucleus.

Books Recommended

- 1. Squire, Fundamental Neuroscience (3rd Edition), Elsevier, 2008
- 2. Kendel, Principles of Neural Science (4th edition), McGraw Hill, 2000

LZT 402 (C): NEUROSCIENCE

Paper IV: DEVELOPMENTAL NEUROBIOLOGY

Unit 1: Major events in early embryonic development: Role of nucleus and cytoplasm, cleavage, formation of blastula and gastrula; Embryonic origin of nervous system, early neural morphogenesis in vertebrates and invertebrates, Compensatory phenomenon in embryonic forms.

Unit 2: Neural Induction: The organizer concept, Molecular nature of the Neural inducer, Conservation of neural induction; Dorsal neural tube and neural crest; Neural crest cells and its derivatives.

Unit 3: Patterning, polarity and regionalization of the nervous system: The anterior-posterior axis and Hox genes, forebrain development, prosomeres and Pax genes; Patterning, polarity and regionalization of the nervous system: Dorsal-ventral polarity in the neural tube;

Unit 4: Neuronal determination and differentiation: Fate mapping of cell determination, differentiation of nerve cells and cell lineage, acquisition of neurotransmitter property and electrical excitability; Neurotrophic factors: Nerve growth factor (NGF), biological system of NGF, agents analogous to NGF in functions, role of NGF as trophic agents, survival factors.

Unit 5: Axon growth, path finding and nerve patterns: Growth Cone, Axonal navigation and axon elongation, cell adhesion molecules, factors influencing axon guidance, target recognition; Synapse formation and elimination: Initiation of synaptic contacts, structure and function of newly formed synapses;- Presynaptic and postsynaptic elements, target selection and synapse elimination; Selective synaptic connections: Skeletal muscle, autonomic ganglia, spinal cord and CNS.

Books Recommended

- 1. Sanes, Development of the Nervous System (2nd Edition), Academic Press, 2006
- 2. Squire, Fundamental Neuroscience (3rd Edition), Elsevier, 2008
- 3. Kendel, Principles of Neural Science (4th edition), McGraw Hill, 2000
- 4. Gilbert, Developmental Biology (7th Edition) Sinnaur Publication, 2006

MAJOR ELECTIVE LABORATORY EXERCISES

LZL 403 (A): MAMMALIAN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY

Hormone Receptors and Signaling Mechanisms

- 1. Study of exocytotic cycle by photomicrographs
- 2. Demonstration of gonadotropin receptors in the ovary by Western blot/ICC
- 3. Demonstration of growth factors in the ovary by Western blot/ICC
- 4. Estrogen bioassay in female rat

- 5. Effect of glucagon and insulin on liver glycogen
- 6. Effects of hormones on lipid metabolism
- 7. Biochemical estimation of nitric oxide by nitrate/nitrite assay

MAJOR ELECTIVE LABORATORY EXERCISES

LZL 403 (B): FISH BIOLOGY

Fish Reproduction, Genetics & Biotechnology

- 1. Determination of fecundity in major carp and catfish
- 2. Determination of fertilization rate of carp
- 3. Determination of final oocyte maturation by scoring germinal vesicle breakdown

4. Study of functional morphology of testes and ovary by preparing permanent stained slides belonging to different reproductive phases

5. Determination of gonosomatic index and hepatosomatic index and their relations with regard to gonadal and body growth

6. Demonstration of induced breeding at a seed production centre

7. Visit to a fish farm and hatchery

Fish Physiology

1. Preparation of permanent stained slides of different endocrine glands and kidney of *Heteropneustes*

fossilis or Clarias batrachus

- 2. Survey of different endocrine glands
- 3. Dissection and display of cranial nerves of Mystus
- 4. Demonstration of pinealectomy in catfish
- 5. Surgical ablation of gonad in a live fish

Inland fishery management

1. Seasonal analyses of pond water by measuring the following physico-chemical properties: Dissolved

CO₂ content, O₂ content, Alkalinity and pH.

- 2. Collection, mounting and study of helminth parasites infecting locally available fishes
- 3. Identification of locally available fishes of economic importance

4. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation.

- 5. Periodic survey of fish market to collect gonad and data related to length weight relationship
- 6. Visit to a fishing site to study the variety of fish catches at different seasons

- 7. Study of fishing nets being used at different seasons
- 8. Determination of protein and lipid contents in a fresh and preserved fish

LZL – 404 (A): Project work/ Dissertation

Topic will be based on the major elective opted by students. Project will include laboratory/field based work followed by submission of report and presentation.

LZL 404 (B): Seminar

Students are required to deliver a seminar on a current topic related to the subject and to be evaluated by a panel of examiners.