### M.Sc. Zoology 2015-2017
#### Choice Based Credit System
Course Structure and Scheme of Examination

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**Major Electives**

(Details will be provided with the syllabus for Sem. III & IV)

**A: Aquatic Biology and Aquaculture**

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**B: CELLULAR NEUROBIOLOGY AND HUMAN GENETICS**

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SEMESTER I
CBCSZ- 101: NON CHORDATA
(Credits 3)

UNIT I
1. Protozoa
   1.1 Nucleus and reproduction
   1.2 Theories of the origin of metazoans
2. Porifera: Aquiferous system
3. Cnidaria: Polymorphism in Siphonophora
4. Annelida
   4.1 Adaptive radiation in polychaetes
   4.2 Trochophore larva

UNIT II
5. Insecta
5.1. Importance and taxonomic richness of insects
5.2. Internal anatomy and physiology
   5.2.1 Nervous system
   5.2.2 Endocrine system and function of hormones
   5.2.3 Circulatory system: heart and haemolymph
   5.2.4 Respiratory system: Aerial respiration and Aquatic respiration
   5.2.5 Digestive system: Structure of gut and Digestion of food
   5.2.6 Excretory system and waste disposal: Malpighian tubules and Nitrogen excretion
   5.2.7 Reproduction: Female and male systems; Oogenesis and spermatogenesis
5.3. Insects as friends and foes
5.4. General methods of insect pest management

UNIT III
6. Insecta
6.1. Sensory system
   6.1.1 Tactile mechanoreceptor and position receptor
   6.1.2 Compound eye
6.2. External anatomy
   6.2.1 Segmentation and tagmosis
   6.2.2 Integument: structure and functions of cuticle, sclerotization
7. Mollusca: Nervous system
8. Arthropoda
   8.1 Evolutionary significance of Trilobites
   8.2 Crustacean larval and their significance

UNIT IV
9. Echinodermata: larval forms and their significance
10. Salient features and affinities of
   10.1 Placozoa
   10.2 Mesozoa
   10.3 Rotifera
10.4 Phoronida
10.5 Sipunculata
10.6 Hemichordata

CBCSZ-102: Chordata
(Credits 3)

UNIT I
1. Characteristic features and affinities of Protochordata and Cyclostomata
2. Origin of the following
   2.1 Fish
   2.2 Amphibian
   2.3 Reptile
   2.4 Bird
   2.5 Mammal

UNIT II
3. Adaptive radiation in vertebrates
   3.1 Aquatic
   3.2 Terrestrial
   3.3 Aerial
   3.4 Arboreal
   3.5 Fossorial
4. Parental care in amphibians
5. Skull in reptiles
6. Migration in birds
7. Flightless birds

UNIT III
8. Comparative anatomy
   8.1 Respiratory system: Characters of respiratory tissue, external and internal respiration,
   8.2 comparative account of respiratory organs
   8.3 Evolution of heart
   8.4 Evolution of aortic arches and portal systems
   8.5 Comparative account of jaw suspensorium and vertebral column

UNIT IV
9. Comparative anatomy
   9.1 Comparative account of limbs and girdles
   9.2 Evolution of urinogenital system in vertebrates
   9.3 Comparative account of organs of olfaction and taste
   9.4 Comparative anatomy of brain and spinal cord (CNS)
   9.5 Comparative account of peripheral and autonomic nervous system
   9.6 Comparative account of lateral line system

Books Recommended
3. Hunter: Life of Invertebrates (1979, Collier Macmillan)

CBCSZ 103: CELL STRUCTURE AND FUNCTION
(Credits 3)

UNIT I
1. Viruses
   1.1 Structure and replication
   1.1.1 Bacteriophage (Lambda phage)
   1.1.2 Animal DNA virus (SV 40)
   1.1.3 Retroviruses (HIV)
2. Prokaryotes
   2.1. Bacteria
   2.1.1 Structure and reproduction of E. coli
   2.1.2 Plasmids and their functions

UNIT II
3. Eukaryotes
   3.1 Cell membrane
   3.1.1 Lipid bilayer and membrane proteins
   3.1.2 Transport across the cell membrane
   3.1.2.1 Diffusion, osmosis and measurement of osmotic pressure
   3.1.2.2 Active transport: mechanism, energy calculations
   3.2 Targeting and sorting of proteins
   3.2.1 Signal peptide and SRP dependent targeting of translational complex
   3.2.2 Processing of proteins in RER
   3.2.3 Processing through Golgi complex: targeting to plasma membrane and lysosome
   3.2.4 Targeting of nuclear and mitochondrial proteins
UNIT III
3.3 Mitochondria
3.3.1 Structure: assemblies of respiratory chain and F₀ F₁ - ATPase
3.3.2 Oxidative phosphorylation: mechanism and chemiosmotic concept
3.3.3 Concept of free energy and bioenergetics of high energy phosphate compounds.
3.4 Cell signaling- Basic concepts
3.4.1 Chemical mediators
3.4.2 Cell surface and Intracellular receptors

UNIT IV
3.5 Apoptosis- Basic concepts
3.5.1 Mechanism: initiation, execution and phagocytosis
3.5.2 Cellular homeostasis, development and diseases
3.6 Cell transformation and malignancy
3.7 Cell - cell adhesion Collagen and Non-collagen components of extra cellular matrix of animal cells, Fibronectins and Integrins, Cell adhesion proteins & their types.
3.8 Cell junctions (occluding, Anchoring & Gap junctions)

Books Recommended
Cell Structure and Function

CBCSZ 104: BIOCHEMICAL & MOLECULAR TECHNIQUES,
BIOSTATISTICS AND BIOINFORMATICS
(Credits 3)
Part A: Biochemical & Molecular Techniques

UNIT I
1. Centrifugation
   1.1 Basic principle
   1.2 Types of rotors
   1.3 Clinical, high speed and ultracentrifuge
2. Spectrophotometry
   2.1 Types of spectrophotometer
   2.2 Beer-Lambert's law, molar extinction coefficient
   2.3 Principles of UV- Vis spectrophotometry
3. Electrophoresis
   3.1 Principle
   3.2 Agarose and polyacrylamide gel
4. Chromatography
4.1 Principle and types  
4.2 Column chromatography  
4.2.1 Gel filtration  
4.2.2 Ion exchange & Affinity chromatography

UNIT II

5. Methods in molecular biology and Recombinant DNA techniques  
5.1 Western blotting & In situ hybridization  
5.2 DNA foot printing & Electrophoretic Shift Assay (EMSA)  
5.3 DNA sequencing  
5.1 Restriction enzymes  
5.2 Cloning vectors  
5.3 Preparation and screening of cDNA and genomic DNA libraries  
5.4 Southern and Northern hybridizations  
5.5 Polymerase chain reaction: principle and applications

6. Types of microscope and their biological applications  
6.1 Bright-field microscope  
6.2 Phase contrast microscope  
6.3 Fluorescence microscope  
6.4 Confocal microscope  
6.5 Transmission and scanning electron microscope

UNIT III

Part B: Biostatics  
7. The mean, mode, median, Standard deviation and Standard error of classified Data  
8. Hypothesis testing: Chi Square test, f-Test  
9. Student’s t test  
10. Analysis of variance (one way and two way ANOVA)  
11. Correlation & Regression

UNIT IV

Section C: Bioinformatics  
12. Bioinformatics: Definition, history and scope  
13. Analysis of DNA and protein sequences; molecular and genomic databases (e.g., GENEBANK, SWISS-PROT and other databases)  
14. Introductory ideas on use of databases for sequence retrieval, similarity search and sequence alignment.  
15. Bioinformatics in drug discovery

Books recommended

Biochemical & Molecular Techniques  
1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumini)  

Bioinformatics
2. Leask: Bioinformatics (2nd ed 2006, Oxford)
4. Mount, Bioinformatics (2nd ed 2006, CBS)

LABORATORY EXERCISES
CBCSZ 105: NON CHORDATA & CHORDATA
(Credits 3)

Part A: Non Chordata & Chordata (Credit 1.5)

Non Chordata
1. Preparation of permanent slides
   1.1 Protozoa: Paramecium (whole mount) and demonstration of food vacuoles, etc.
   1.2 Cnidaria: Bougainvillea, Sertularia, etc.
   1.3 Arthropoda: Cyclops, Megalopa/Zoea, spiracles of cockroach, etc.
   1.4 Mollusca: Glochidium larva, etc.
   1.5 Echinodermata: Spherdium, pedicellaria, tube-feet
2. Dissections
   2.1 Arthropoda: Salivary glands of cockroach, etc.
   2.2 Mollusca: nervous system of Mytilus and Aplysia/Sepia
3. Study of museum specimens
   3.1 Porifera
   3.2 Cnidaria
   3.3 Annelida
   3.4 Arthropoda
   3.5 Mollusca
   3.6 Echinodermata

Insects
1. Study of external morphology of cockroach
2. Internal anatomy of cockroach
   2.1 Alimentary canal
   2.2 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

Chordata
1. Study of external features of Branchiostoma and permanent preparation of its oral hood, velum and pharyngeal wall
2. Study of whole mount preparations of following proto-chordates
   2.1 Doliolium, Pyrosoma, Salpa and Oikopleura
   2.2 T.S. through pharynx, gonads and post anal region of Branchiostoma
   2.3 T.S. and L.S. through proboscis of Balanoglossus
3. Permanent preparation of test and neural complex of Herdmania
4. Fossorial adaptation and urino-genital system of rat
5. Study of adaptive features of following:
   5.1 Amphibians
   5.2 Reptiles
   5.3 Birds
   5.4 Mammals

Fish Biology
1. Classification of the following locally available fishes using key
   1.1 Carps: Ctenopharyngodon idella, Labeo rohita, Cirrhina mrigala
   1.2 Catfishes: Heteropneustes fossilis, Clarias batrachus
2. Dissection and display of accessory respiratory organs of
   2.1 Clarias batrachus
   2.2 Channa sp.
   2.3 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 airbreathing organs
6. Study of T.S. of gills, accessory respiratory organs and swim bladder from prepared slides

CBCSZ106: BIOCHEMICAL AND MOLECULAR TECHNIQUES
(Credits 3)

Biochemical and Molecular Techniques
1. Verification of Beer’s law and preparation of absorption spectrum of riboflavin
2. Demonstration of separation of protein by SDS-polyacrylamide gel electrophoresis
3. Isolation of plasmid, restriction digestion and determination of size by agarose gelelectrophoresis
4. pH meter and determination of pH of a buffer
5. Demonstration of DNA amplification by polymerase chain reaction
6. Isolation of genomic DNA by spooling/precipitation method and its quantitation
7. Agarose gel electrophoresis
8. Isolation and identification of lipids by TLC
9. Determination of amino acids by paper chromatography
10. Estimations of fractionated molecules through spectrophotometric methods
   10.1 Protein by Biuret/Folins method
   10.2 DNA by diphenylamine method
   10.3 RNA by orcinol method

**Bioinformatics & Biostatistics**

1. Use of search engines (Google, Altavista, Dogpile, Meta-crawler)
2. Demonstration of web-pages related to biological information (NCBI, ExPasy)
3. Hands on practice to features of following databases: GenBank, PDB, DIP, PubMed, Toxnet, OMIM, Fly Base, etc.
4. Hands on practice to features of following software packages/tools: BLAST, Clustal-W, PHYLIP
5. Estimation of mean, median, mode, standard error and standard deviation
6. Demonstration of correlation
7. Working on examples of $X^2$ (Chi square) test for hypothesis testing
SEMESTER II
ZOM201: CYTOGENETICS AND GENETICS
(Credits 3)

UNIT I
1. Eukaryotic chromatin structure and chromosome organization
   1.1 Classes of DNA
   1.2 Chromosomal proteins: histones, non-histone proteins and scaffold/matrix proteins
   1.3 Nuclear matrix and organization of interphase nucleus
   1.4 Centromere, kinetochore and telomere
   1.5 Metaphase chromosome banding
2. Giant chromosome: Polytene chromosome & Lampbrush chromosome
3. Cell division
   3.1 Mitosis
   3.1.1 Role of maturation promoting factor and its regulation
   3.1.2 Chromosomal movement
   3.1.3 Exit from mitosis
   3.1.4 Cytokinesis
   3.2 Meiosis
   3.2.1 Chromosome pairing and recombination
   3.2.2 Genetic regulation

UNIT II
4. Human cytogenetics
   4.1 Karyotype and nomenclature of metaphase chromosome bands
   4.2 Chromosome anomalies and diseases
   4.2.1 Types of chromosomal anomalies
   4.2.2 Common syndromes caused by aneuploidy, mosaicism, deletion and duplication
   4.2.3 Chromosomal anomalies in malignancy (chronic myeloid leukemia and retinoblastoma)
   4.2.4 Fragile site and X-linked mental retardation

UNIT III
5. Mendel’s laws and their chromosomal basis
6. Extensions of Mendelism
   6.1 Dominance relationships
   6.2 Epistasis
   6.3 Pleiotropy
7. Methods of gene mapping
   7.1 3-point test cross in Drosophila
   7.2 Gene mapping in bacteria by transformation and conjugation
8. Quantitative inheritance: Concept of polygene & polygenic inheritance

UNIT IV
9. Gene mutation and DNA repair
   9.1 Types of gene mutations
   9.2 DNA damage and repair
10. **Nature of the gene and its function**
   10.1 Fine structure of gene (rII locus)
   10.2 Regulation of gene activity in lac operon of *E.coli*
   10.3 Organization of a typical eukaryotic gene
   10.4 Non-coding genes

11. **Mitochondrial DNA: Organization & properties**

**Books Recommended**
3. Cassimeris et al: Lewin’s Cells (2011, Jones Bartlet)
11. Russell: Genetics (2010, Benjamin Cummings)

**CBCSZ 202: DEVELOPMENTAL BIOLOGY**
(Credits 3)

**UNIT I**
1. Introduction to Development: Generation of new cells and organs.
2. Cell-Cell communication in development, cell adhesion, cell migration, cell signaling, paracrine factors.
4. Cleavage: Pattern of cleavage, fate map, cleavage and axis formation in *C. elegans*.

**UNIT II**
5. Early development in Fish and Amphibians: Axis fate in Zebra fish, Amphibian cleavage and Gastrulation, mechanism of Amphibian axis fate.
6. Early development in Birds: Gastrulation in Avian embryo, Axis fate
7. Mammalian Gastrulation, Mammalian Axis fates.

**UNIT III**
10. Neural Crest Cells, Pattern generation in nervous system.
11. The Somites and their Derivatives.
15. Formation and development of Limbs

UNIT IV
17. Regeneration in Flat worms, Hydra, Salamander
18. Cancer
19. Environment and Development
20. Developmental Mechanisms of Evolutionary Change

CBCSZ 203: HISTOLOGY AND MOLECULAR HISTOCHEMISTRY

(Credits 3)

UNIT I
1. Fixation and tissue processing
   1.1 Types of fixatives
   1.2 Chemistry of fixation
   1.3 Choice of fixatives
   1.4 Dehydration
   1.5 Clearing and embedding

2. Microtomy
   2.1 Types of microtome
   2.2 Sectioning of paraffin blocks
   2.3 Cryosectioning
   2.4 Vibratome

3. Staining of paraffin sections
   3.1 Principle and methods of staining
   3.2 Histological stains: haematoxylin and eosin

UNIT II
4. Principles and methods of histochemical localization and identification of:
   4.1 Carbohydrate moieties
   4.1.1 Glycogen and glycoproteins with oxidizable vicinal diols by periodic acid Schiff method
   4.1.2 Glycoproteins with carboxyl groups and/or O-sulphate esters by alcian blue methods
   4.1.3 Role of lectin in carbohydrate histochemistry
   4.2 Protein end groups
   4.2.1 General protein localization by bromophenol blue method
   4.2.2 -NH₂ groups by Ninhydrin-Schiff method
   4.2.3 - S-S- groups by performic acid-Schiff and performic acid-alcian blue methods

UNIT III
4.3 Lipids moieties
   4.3.1 General lipids by Sudan black B method
   4.3.2 Neutral lipids by Sudan III and Sudan IV methods
   4.3.3 Differentiation of neutral lipids from acidic lipids by nile blue sulphate method
4.4 Nucleic acids
4.4.1 Methyl green pyronin-Y for DNA and RNA
4.4.2 Feulgen reaction for DNA
4.5 Enzyme activity
4.5.1 Principles of enzyme histochemistry
4.5.2 Acid and alkaline phosphatases by metal precipitation and azo dye methods

5. Basic principles of immunohistochemistry and fluorescence staining
6. In situ hybridization

UNIT IV
7. Gross Histology of tissue types:
   7.1 Connective tissue
   7.2 Cartilage
   7.3 Bone
   7.4 Cerebrum, cerebellum and spinal cord
   7.5 Heart
   7.6 Kidney
   7.7 Liver
   7.8 Gall bladder
   7.9 Lungs
   7.10 Testis and ovary
   7.11 Thyroid gland

Books recommended
Histology & Histochemistry
2. Casselman: Histochemical techniques (1959, John Wiley)

CBCSZ204: BIOCHEMISTRY & MAMMALIAN PHYSIOLOGY
(Credits 3)

Part A: BIOCHEMISTRY

UNIT I
1. Protein structure
   1.1 Primary structure
   1.2 Secondary structure: α-helix, β-pleated sheet
   1.3 Tertiary structure: forces stabilizing tertiary structure
   1.4 Quaternary structure: sub unit interaction and significance
2. Enzymes
   2.1 Classification and nomenclature
   2.2 Enzyme kinetics: Michaelis-Menten and Lineweaver-Burk plots, applications of Km
   2.3. Mechanism of action
   2.3.1 Active site & substrate binding.
2.3.2 Chemical catalysis (chymotrypsin)
2.3.3 Regulation of enzyme activity

UNIT II
3. Metabolism
3.1 Concept of metabolic pathways and cycles
3.2 Central energy transduction mechanism
4. Nucleic acids
4.1 Structure
4.2 Mechanism of DNA replication
4.2.1 DNA polymerases
4.3 Transcription
4.3.1 RNA polymerases and mechanism of RNA synthesis
4.4 Processing of hnRNA: Capping Poly(A) tailing & Splicing
4.5. Genetic code
4.6. Mechanism of translation
4.6.1. Role of ribosomes and tRNAs
4.6.2 Mechanism of transition in prokaryotes & eukaryotes

Part B: MAMMALIAN PHYSIOLOGY

UNIT III
5. Circulation
5.1 Blood: Haemopoiesis
5.2 Heart
5.2.1 Origin and conduction of cardiac impulse
5.2.2 Cardiac cycle and ECG
6. Respiration
6.1 Pulmonary ventilation
6.1.1 Respiratory centers: organization and function
6.1.2 Surfactant
6.2. Exchange and transport of respiratory gases
6.3 Respiratory adjustments
6.3.1 Hypoxia and oxygen therapy
6.3.2 Dyspnea

UNIT IV
7. Excretion
7.1 Urine formation and regulation
7.2 Acid-base balance and homeostasis
7.3 Renal function tests
8. Muscle
8.1 Types of contraction
8.2 Muscle proteins
8.3 Mechanism and energetics of muscle contraction
9. Digestion and nutrition: Digestion and absorption of macronutrients and their regulation

Books Recommended
Mammalian Physiology
5. West: Best and Taylor's Physiological Basis of Medical Practice (11th Ed 1981, Williams and Wilkins)

Biochemistry


LABORATORY EXERCISES

CBCSZ 205: CYTOGENETICS, GENETICS AND DEVELOPMENTAL BIOLOGY
(Credits 3)

Cytogenetics
1. Study of meiosis in grasshopper testes by squashing method
2. Temporary squash preparation of polytene chromosomes from salivary glands of Drosophila/ Chironomous larvae
3. Preparation of human karyotype
4. Study of sex chromatin in human female from buccal epithelial and hair budcells
5. Study of permanent slides for the following:
   5.1 Inversions in polytene chromosomes of Drosophila
   5.2 G-banded and C-banded metaphase chromosomes

Genetics
1. Culturing of E.coli on solid and liquid media
2. Handling of Drosophila and study of its life cycle
3. Examination of wild type (males and females) and mutants of Drosophila
4. Sex linked inheritance in Drosophila melanogaster
5. Monohybrid and di-hybrid crosses in Drosophila melanogaster

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. Study of embryonic development in chick through slides
5. Window preparation to study chick embryo development
6. Whole mount preparation of chick embryos at various stages of development
7. Observation of aristapedia and bithorax mutants of Drosophila
8. Study of metamorphosis in Drosophila larvae by ligature experiments

CBCSZ 206: HISTOLOGY, HISTOCHEMISTRY, BIOCHEMISTRY AND PHYSIOLOGY
(Credits 3)

Histology and Histochemistry
1. Paraffin sectioning
   1.1 Fixation of tissue
   1.2 Dehydration, clearing and embedding of tissue
   1.3 Sectioning and spreading of sections
2. Histological staining of paraffin sections using haematoxylin and eosin method
3. Histochemical staining of paraffin sections for demonstration of acidic glycoproteins by Alcian blue pH 2.5 method
4. Histochemical staining for lipids using
   4.1 Sudan black B method
   4.2 Sudan III method
   4.3 Sudan IV method
5. Demonstarition of immunohistochemical and immunofluorescence methods

Biochemistry & Physiology
1. Preparation of extract for enzyme assay (alkaline phosphatase)
2. Study of alkaline phosphatase activity
   2.1 Standard curve preparation
   2.2 Effect of enzyme concentration and determination of total and specific activity
   2.3 Effect of temperature on enzyme activity
   2.4 Effect of time on enzyme activity
   2.5 Effect of substrate concentration on enzyme activity
   2.6 Determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk
3. Differential leucocytes counting in blood
4. Determination of blood groups (ABO and Rh factor)
5. Estimation of ascorbic acid content in lemon extract using titration method
6. Preparation of casein from milk