

FACULTY OF SCIENCE
Department of ZOOLOGY

NEW SYLLABUS

(For M.sc. ZOOLOGY, Batch admitted from the academic year 2014-2015)

| Paper | Title of the Paper |
|-----------------------|---|
| SEMESTER – I | |
| I | Biosystematics, Structure & Function of Invertebrates |
| II | Tools and Techniques in Biology |
| III | Animal Physiology and Ethology |
| IV | Genetics and Evolution |
| SEMESTER – II | |
| I | Structure and Function of Vertebrates |
| II | Environmental Biology |
| III | Biochemistry |
| IV | Biostatistics and Computer Applications |
| SEMESTER – III | |
| I | Immunology |
| II | Cell Biology |
| III | Histochemistry |
| IV | Molecular Biology |
| SEMESTER – IV | |
| I | Endocrinology and Reproductive Biology |
| II | Developmental Biology |
| III | Animal Biotechnology |
| IV | Fisheries and Aquaculture |
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ELECTIVES OFFERED

1. Toxicology
2. Wildlife Biology
3. Aquatic Biology
4. Fisheries
5. Soil Biology and Ecology
6. Neuro Physiology
7. Entomology
8. Enzymology
9. Infectious Diseases and Metabolic Disorders
10. Bioinformatics
11. Nano-biotechnology
12. Environmental Biotechnology
13. Parasitology.

Faculty of Science
M.Sc, Zoology
SEMESTER – I
PAPER – I

BIOSYSTEMATICS, STRUCTURE & FUNCTIONS OF INVERTEBRATES

Unit – I: Biosystematics and Applications

- 1.1. Basic principles of classification.
- 1.2. Species concept Mechanism of speciation. Allopatric and Sympatric speciation.
- 1.3. Apomictic species and Panmictic species.
- 1.4. Typification and different types of zoological types. Taxonomic keys

Unit –II: Nutrition & Respiration

- 2.1 Patterns of feeding and digestion in metazoan.
- 2.2 Filter feeding in polychaeta
- 2.3 Modifications in the digestive system of invertebrates with Special reference to modifications in Arthropoda & Mollusca
- 2.4 Respiration: Respiratory pigments, Organs of respiration-gills, trachea and lungs, mechanism of respiration

Unit – III: Excretory and Nervous systems

- 3.1 Organs of excretion- coelome, coelomoducts, Nephridia, Malpighian tubules.
Mechanism of excretion and osmoregulation
- 3.2 Nervous system: coelenterates and Echinodemata
- 3.3 Nervous system: arthropods (Crustaceans and insects) and Molluscs Cephalopoda)
- 3.4 Trends in Evolution of nervous system.

Unit – IV: Minor phyla and invertebrate larvae

- 4.1 General organization and affinities of Mesozoa, sipunculida and chaetognatha
- 4.2 Larval forms of free living invertebrates (Coelenterata, Annelida, Arthropoda, Mollusca and Echinodermata)
- 4.3 Larval forms of helminth and crustacean parasites,
- 4.4 Evolutionary significance of larval forms

PRACTICALS :

1. Observations of nervous system development from lower to higher invertebrates and write the identified modifications in the record. Dissection of the following
 - a) Nervous system of Leech
 - b) Nervous system of Cockroach & Reproductive system
 - c) Nervous system of Aplysia
 - d) Nervous system of Unio
 - e) Nervous system of Crabs
 - f) Nervous system of Sepia
2. Modifications of Mouth parts in insects. Separate the mouth parts from the insects, mount and observe the modifications and write the adaptations – Chewing, Piercing and Sucking etc.
3. Collect 10 invertebrates and prepare permanent slides and submit in the examinations (Parasites – 5 and Non-parasites – 5).
4. Museum specimens (from each phylum not less than 10 specimens ,Protozoa to Echinodermata).
5. Slides and preserved animals (from each phylum not less than 5 slides).
6. Karyotype studies for Numerical Taxonomy.
7. Hemoglobin Variation in different phyla for Evolutionary Studies.
8. Species variation – *Drosophila Variants*.
9. Collection of Termites to observe variants.
10. Collection of Fresh Water Molluscs.
11. Collection of Endo- parasites for species variations *Trypanosomes* from Rats

REFERENCE BOOKS

1. Invertebrate Zoology ----- EL Jordan; P.S. Verma
2. A Text Book of Zoology Vol.I ----- P.S. Dhami; Jk.Dhami.
3. A Text Book of Invertebrate zoology ----- R.L.Kotpal.
4. Biology of Animals --- Cleveland P. Hickman JR Larryds. Roberts.

Faculty of Science
M. Sc, Zoology
SEMESTER – I
PAPER – II
TOOLS AND TECHNIQUES IN BIOLOGY

Unit – I: Instrumentation in Biology

- 1.1. Centrifugation: Principle and applications of Centrifugation; differential and density gradient Centrifugation..
- 1.2. Electrophoresis: Principle, structural components and applications of electrophoresis.
- 1.3. Chromatography: Principle and applications of chromatography; adsorption, Ion exchange, gel permeation and affinity.
- 1.4. Spectrophotometer: Principle, PH meter and applications of Spectrophotometer.

Unit –II: Microscopy and Histological techniques in Biology

- 2.1. Microscopy: Principle, and applications of different types of microscopes Light, Phase Contrast, Electron: SEMUTEM
- 2.2. Microtome: Types and applications. Collection & preservation of animal tissue – fixation, embedding, Sectioning, Staining, Identification of deferent components.
- 2.3. Tissue preparation for light microscopy.
- 2.4. Cryotechniques: History and applications of Cryotechniques, Cryoultramicrotomy.

Unit – III: Cell Culture Techniques

- 3.1 Cell Culture System , and History of development of cell culture
- 3.2 Natural surroundings and metabolic capabilities animals' cell.
- 3.3 Commonly used Cell Lines and their Uses.
- 3.4 Transplantation of Cultured Cell.

Unit – IV: Radiation techniques in Biology

- 4.1. GM (Geiger-Muller) Counter – Description and Applications
- 4.2. Scintillation Counter – Description and Applications.
- 4.3. Autoradiography – Method and applications.
- 4.4 Principle and applications of Biosensors.

Practicals

1. Separation of cell organelles by Differential centrifugation
2. Separation of protein by electrophoresis (native & SDS page)
3. Separation of amino acids by paper and thin layer Chromatography Demonstration of column . Chromatography
4. Validation of Beer-Lambert's law of a coloured compound (CuSO_4)
5. Measurement of pH meter Preparation of buffer
6. Light microscope and its parts Observation of unstained and stained cells (peel of onion etc)
7. Demonstration of fixation, dehydration, sectioning and staining of any animal tissue (liver)
8. Demonstration of Carbohydrates, Proteins Lipids and nucleic acids in tissue sections.
9. Preparation of chick fibroblast culture and viability testing.

REFERENCE BOOKS

1. Principles and Techniques in biochemistry and molecular biology Wilson & Walker
2. Culture of animal cells Freshney
3. Sharma V.K.(1991), Techniques in microscopy and cell Biology, Tata-Mc Graw Hill.
4. Robert Braun Introduction to instrumental analysis Mc.Graw.Hill
5. Bisen & Mathw. Tools and Techniques in Life Sciences, CBS Publishers & distributors.
6. Principles of animal cell culture , Basant Kumar & Rinesh Kumar, Int. Bork 2008, XXII edn.

**FACULTY OF SCIENCE
M.Sc. ZOOLOGY,
SEMESTER - I
PAPER – III**

ANIMAL PHYSIOLOGY AND ETHOLOGY

Unit – I: Digestion and Respiration

- 1.1. Functional anatomy of digestive system.
- 1.2. Digestion and absorption. Neuroendocrine regulation of gastro – intestinal movements and secretions.
- 1.3. Breathing movements and exchange of respiratory gases at the pulmonary surface. Respiratory quotient Respiratory Pigments Transport of respiratory gases
- 1.4. Neural and hormonal control of breathing. Respiratory acidosis and alkalosis and regulation of blood PH.

Unit –II: Circulation and Excretion

- 2.1. Cardiac physiology: physiology of heartbeat, Rhythmicity, and diseases associated with heart.
- 2.2. Components of blood and functional significance. Cascade of biochemical reactions (factors) involving in blood coagulation.
- 2.3. Functional anatomy of mammalian kidney and its renal units. Physiology of urine formation. The significance of Henley's loop. Role of hormones in renal physiology.
- 2.4. Formation of nitrogenous excretory products NH₃, Urea & Uric acid.

Unit – III: Neuro – Muscular Physiology

- 3.1 Structure of neuron, Fundamentals of nerve impulse- resting potential , Action potential, role of ion channels.
- 3.2 Types of synapses- electrical and chemical, gap junctions , ligand gated channels and the mechanism of synaptic transmission, cholenergetic and adrenergic, Neuromuscular junction
- 3.3 Types of muscles: striated, nonstriated and cardiac muscles. Ultra structure of striated muscle.
- 3.4 Muscle contraction – Muscle proteins, sliding filament theory, Energetics of muscle contraction.

Unit – IV: Ethology

- 4.1 Definition of ethology. Introduction and History of ethology. Ethology Vs behaviourism. Instinct Vs Learning.
- 4.2 Evolution of communication: **Dance** language of honeybees, pheromones, and aggression.
- 4.3 Foraging and Predation. Defensive secretions in Insect.
- 4.4 Social behavior in Insects.

PRACTICALS

1. Action of pepsin in digestion of proteins.
2. Estimation of salivary amylase activity.
3. Estimation of lipase activity.
4. Oxygen consumption and estimation in an aquatic or terrestrial animal.
5. Demonstration of fermentation.
6. Action of insulin on blood sugar level.
7. Experiments on urine analysis in human urine sample:
 - a) Test for urea, blood cells, bile salts, albumin, ketone bodies and sugar in human urine sample.
8. Determination of cell fragility by osmotic hemolysis experiment.
9. Identification of relation between temperature and heart beat in freshwater mussel.
10. Water and ionic regulation of freshwater animal in different osmotic media.
11. The Study of changes in the earthworm's responsiveness to the stimulus of touch.
12. Observation of an earthworm's responses in the cases of repeated stimulation and dual stimulation.
13. Observation of the response of invertebrates to different lighting conditions.

REFERENCE BOOKS

1. Animal Physiology ----- Samson & Writy
2. Animal Physiology ----- Nelson & Nelson
3. Animal Physiology ----- Medical Physiology-Guiton
4. Text book of Animal Physiology ----- Nagbhushenen
5. Text book of Animal Physiology ----- Guize
6. Text book of Animal Physiology ----- A.K. Berry.

FACULTY OF SCIENCE
M.Sc. Zoology
I- Semester
Paper-1V
GENETICS AND EVOLUTION

Unit I: Genetics

- 1.1. Interaction of Genes- epistasis, genes and environment, Lethality, Meiotic drive, pleiotropism, polygenic inheritance, Extra chromosomal inheritance
- 1.2. Linkage and Crossing Over - coupling, testcross, linkage maps, recombination, cytological basis for crossing-over
- 1.3. Chromosomal aberrations- Structural and numerical changes
- 1.4. Gene mutations – in drosophila and man.

Unit II: Population Genetics

- 2.1. Genetic structure of populations –Gene pool, Genotype Frequency, Allelic frequency, kinds of selection, Fisher's theorem, genetic variability, canalization, genetic load, genetic death,
- 2.2. Gene Frequency and Genetic Equilibrium – Hardy Weinberg Law, conservation of gene frequency co-dominance and dominance in natural populations
- 2.3. Changes in gene frequency - mutation, fitness, genetic drift, migration, selection, heterozygous advantage, inbreeding depression
- 2.4. Genetic variation in natural populations- Protein level and DNA level

Unit III: Molecular Evolution

- 3.1. Molecular phylogeny- Immunological techniques, amino acid sequences, nucleic acid phylogeny
- 3.2. Patterns and modes of substitution- (Nucleotide substitutions, Evolutionary rate, molecular clock
- 3.3. Phylogenetic trees, construction method, Multigene families, phylogenetic gradualism, punctuated equilibrium, phylogenetic classification, phenetics, cladistics
- 3.4. Induced Changes in genetic material- ionizing and UV radiation, chemical mutagens, Oxygen and environmental effects, DNA repair, induced mutations in humans

Unit IV: Concepts of Evolution

- 4.1. Lamarckism, Neo Lamarckism, Darwinism, Neo Darwinism, Natural Selection
- 4.2. Modes of speciation, Isolating Mechanism

4.3. Origin of unicellular and multicellular organisms, plants and animals

4.4. Primate and human evolution, Eugenics, Evolution by genetic engineering.

PRACTICALS:

1. Problems based on multiple alleles – Blood groups
2. Problems based on Mendel's Laws – monohybrid and dihybrid ratios
3. Problems based on gene frequency – Hardy Weinberg Law
4. Karyotype studies
5. Haemoglobin variations
6. Insulin variations
7. Collection of termites to observe variants

REFERENCE BOOKS:

1. Genetics by Monroe W Strickberger
2. Evolution by Monroe W Strickberger
3. Genetics by Peter J Russell
4. Evolution by Dobzhansky, Ayala, Stebbins, Valentine
5. Genetics by P.K.Gupta
Human molecular Genetics by Tom Strachan and Andrew Rea

**FACULTY OF SCIENCE
M.Sc. ZOOLOGY,
SEMESTER - II
PAPER – I**

STRUCTURE AND FUNCTIONS OF VERTEBRATES

Unit – I: Chordates, Proto chordates and Vertebrate Integument

- 1.1 Characters and Classification of proto-chordata, significance of protochordates in the evolution.
- 1.2 Origin of chordates and classification
- 1.3 Vertebrate integument, development, structure of skin in vertebrates.
- 1.4 Derivatives of Integument glands, scales, horns, claws, hoofs, feathers & hair.

Unit – II: Skeletal and Digestive system

- 2.1 Comparative account of jaw suspension
- 2.2 Comparative account of vertebral column
- 2.3 Comparative account of girdles and limbs.
- 2.4 Anatomy of gut in relation of to feeding habits- herbivores, carnivores and omnivores.

Unit – III: Circulation and respiration

- 3.1 Evolution of heart
- 3.2 Evolution of aortic arches and portal system
- 3.3 Respiratory organs in fishes and amphibians
- 3.4 Air sacs in birds

Unit – IV: Nervous and Urino-genital systems

- 4.1 Comparative anatomy of brain in relation to its function
- 4.2 Nerves - cranial, peripheral and Autonomous nervous system
- 4.3 Sense organs, simple receptors, organs of olfaction and taste, Lateral line system and Electric organs
- 4.4 Evolution of Urino-genital system in vertebrate series.

PRACTICALS

1. Cranial Nerves of Labeo (5th and 7th and 9th and 10th weberian oscicles)
2. Dissection demonstration of Brain and Heart of Fish, Calotes, Chick and Rat
3. Demonstration of flight muscles and Air Sacs in Birds.
4. Demonstration Vascular and urinogenetal system of Rat.
5. Collect 10 vertebrates and submit in the examinations
6. Museum specimens (from each Class not less than 15 specimens).
7. Slides related to vertebrate parts.
8. Mounting of Amphioxus, Doliolum and Scales of fishes.
9. Sketelation System (Vertebra , limbs, Girdles)

REFERENCE BOOKS

- 1 Vertebrate Zoology ----- EL Jordan; P.S. Verma
- 2 A Text Book of Zoology Vol.II ----- P.S. Dhami; Jk.Dhami.
- 3 A Text Book of Vertbrate zoology ----- R.L.Kotpal.
- 4` Biology of Animals --- Cleveland P. Hickman JR Larryds. Roberts.

**FACULTY OF SCIENCE
M.Sc. ZOOLOGY,
SEMESTER - II
PAPER – II**

ENVIRONMENTAL BIOLOGY

Unit – I: Fundamental of the Ecosystem

- 1.1. Structure and functions of the Ecosystem – abiotic and abiotic interactions, energy flow, cycling of nutrients in ecosystems (biogeochemical cycles, N C P)
- 1.2. Major types ecosystems – aquatic (lentic and lotic ecosystems), terrestrial ecosystems (forest, grass land, desert ecosystems).
- 1.3. Primary production and decomposition).
- 1.4. Population and ecology: characteristics of a population. population growth curves population regulation. Nature of communities; Community structure and attributes, levels of species diversity edges ecology.

Unit – II: Environmental Pollution and Management

- 2.1. Environmental Pollution -- Water and Soil Pollution – sources of pollutions, effects and control measures of pollutions.
- 2.2 Global Environmental Problems – Global Climate Change and biodiversity ; status;major drivers of biodiversity change; biodiversity change; biodiversity management approaches.
- 2.3 Environmental Laws related to water, air, and soil.
- 2.4 Natural resources and their management – renewable and Non-renewable resources.
- 2.5 Conservation biology : principles of conservation; major approaches of management, case studies on conservation /management strategy (Tiger projects)

UNIT – III: Ecotoxicology

- 3.1. Classification of toxins, Assessment of toxicity – Acute and chronic toxicity, LC₅₀ and LD₅₀ assessment, dose response relationship for toxicity assessment
- 3.2. Molecular mechanism of toxicant action.
- 3.3. Biomagnifications – Bioaccumulation of toxic use and risk assessment.
- 3.4. Impact of pollution on bioindicator species,

Unit – IV: Waste Treatment Technology

- 4.1. Sewage and waste water treatment – Aerobic and anaerobic treatment technologies
- 4.2. Sources and causes of solid waste and treatment of solid waste.
- 4.3. Bioremediation – advantages and disadvantages, In-situ and ex-situ bioremediation of contaminated soils.
- 4.4 Vermin technology use in waste treatment.

PRACTICALS

1. Collection and identification of animal Biodiversity of selected ecosystem.
2. Physico-chemical analysis of soil pH, soil moisture soil , temperature, humidity estimation soil, soil organic matter.
3. Air Monitoring – Particulate Matter.
4. Water Monitoring - five important parameters from drinking water. 1) Dissolved Oxygen 2) Biological Oxygen demand (B O D) 3) Chemical Oxygen demand 4) Chlorides 5) salinity.
5. Bio remediation of waste water using soil micro organisms ..
6. Bioconversion of municipal waste by vermi-composting.
7. Collection, preservation and estimation of Zooplankton.
8. Mapping of national parks and wild life sanctuaries in India with a note of important wild life fauna.
9. Estimation of LC₅₀ or LD₅₀ of an organo phosphorous pesticide.
10. Determination of pesticide residues in soil or water.

REFERENCE BOOKS:

1. Fundamental of Ecology. E.p.odum, G W Barrett.
2. Environmental Science . Willam .P.Cunninsham Barbora woodworth saigo.
3. The use of Earthworms in waste disposal by . Edward, C.A.
4. Introduction to Environmental Engineering & Science Gilbert M. Masters.
5. Essential of Ecology by colin R. Townsend Michael Begon John.L.Harper.
6. Environmental Biology -- A.G.Agarwal.
7. Environmental Science by G.Tyler Miller.
8. Toxicology -- Y.K.Lahir.

FACULTY OF SCIENCE
M.Sc. ZOOLOGY,
SEMESTER - II
PAPER – III

BIO-CHEMISTRY

Unit- I: Biomolecules :

- 1.1. Carbohydrates – Monosacharides, disacharides and polysaccharides
- 1.2 Proteins- Classification and structure, Amino acids classification and general characters.
- 1.3 Lipids- classification and functions of lipids and fatty acids
- 1.4 Nucleic acids – purines, pyrimidines, nucleotides, structure of DNA & RNA and types of RNA, Biosynthesis and degradation of purines and pyrimidines

Unit- II: Enzymes:

- 2.1. Nomenclature and classification of enzymes, vitamins as co-enzymes.
- 2.2. Enzyme Kinetics – Michales –Menten equation. Determination of Vmax and Km, Factors affecting the enzyme activity
- 2.3.Enzyme inhibition – Competitive & non-competitive
- 2.4. Mechanism of enzyme action – active sites, Chymotrypsin as a model, Regulation of enzyme activity, allosteric enzymes, PFK, ATC (Phosphofructokinase /Aspartate trans carbamylase)

Unit-III: Bioenergetics:

- 3.1. Basic Principles of thermodynamics free energy, Enthalpy and Entropy
- 3.2 Redox Potential and electron transport
- 3.3. ATP- Production (Chemiosmotic model), high energy phosphates
- 3.4. Coupled reactions

Unit-IV: Metabolism :

- 4.1. Carbohydrate metabolism,- Glycolysis, Krebs cycle, pentose Phosphate pathway, Glycogenesis, Glycogenolysis, Gluconeogenesis, hexomonophosphate shunt, 4.2.Protein metabolism – Transamination and deamination, incorporation of amino acids into TCA cycle, integration between urea cycle and TCA cycle.
- 4.3. Lipid metabolism – fatty acid oxidation and biosynthesis, ketone bodies
- 4.4 metabolic defects of carbohydrate and amino acid metabolism.

PRACTICALS:

1. Estimation of muscle and liver glycogen
2. Estimation of protein by Biuret and Lowry methods
3. Estimation of amino acid by Ninhydrin method
4. Estimation of serum total cholesterol
5. Estimation of vitamin – C by 2,6- dichlorophenol indophenols method
6. Estimation of Ammonia (nesslerisation method) and uric acid
7. The effect of Ph and temperature (α -amylase) activity
8. The effect of concentration of enzyme (trypsin) activity

REFERENCE BOOKS:

1. Principles of biochemistry, by Lehninger
2. Biochemistry , by Donald Voet and Judith Voet.
3. Biochemistry , by Harper.
4. Biochemistry . Jeremy M.Berg, JohnL.Tymovzko, Lubert Stryer

**FACULTY OF SCIENCE
M.Sc. ZOOLOGY,
SEMESTER - II
PAPER – IV**

BIostatISTICS AND COMPUTER APPLICATIONS

Unit – I: Biostatistics

- 1.1. Introduction to Biostatistics – Definition, Terms, Applications and Role of biostatistics in modern research.
- 1.2. Measures of Central Tendency (Mean, Median and Mode) and Dispersion (Standard Deviation).
- 1.3. Student's t-Test, Chi-square test.
- 1.4. Correlation, Linear Regression and Logistic Regression.
- 1.5. Analysis of Variance – Types of ANOVA and classes of ANOVA models.

Unit – II: Basics of Computers

- 2.1. Basic components of computers – Hardware (CPU, input, output storage devices), Software (operating systems).
- 2.2. Introduction to MS EXCEL – use of worksheet to enter data, edit data, copy data, move data and Graphical tools in EXCEL for presentation of data.
- 2.3. MS – WORD – editing, copying, moving, formatting, table insertion, drawing flow charts etc.,
- 2.4. Introduction to Power Point, image, data handling and Graphical tools in PPT for presentation.
- 2.5. Use of Computers in Data Processing and Mapping

Unit – III: Internet Basics

- 3.1. Introduction to Internet – Basics and Applications of Internet, Internet working Internet access.
- 3.2. Using of Internet – Understanding the basics, title, menu and tool bars, Addresses/address bar, Navigating web pages and Web sites and Printing.
- 3.3. Understanding the World Wide Web (WWW).
- 3.4. Searching Tools – World Search Engines, Search Directories and Encyclopedias.
- 3.5. Online safety – spywares and viruses.

Unit – IV: Bioinformatics

- 4.4. Introduction, scope and applications of bioinformatics.
- 4.5. Biological databases – Protein and DNA sequences data bases; importance.
- 4.6. Genomics – Definitions, Pharmacogenomics, taxicogenomics, human genomics, prokaryotic and eukaryotic genomes and genome relationships.
- 4.7. Proteomics – Definitions, Transcriptomics and metabolomics, Proeomics techniques (2D PAGE).
- 4.8. Computational Biology – Multiple Sequence Analysis and Phylogenetic alignmen

PRACTICALS

(a) Statistics

1. Problems on Mean and Median.
2. Problems on Standard Deviation.
3. Problems related to X² test, Student T Test . And Probuality
4. Problems on Correlation.

(b) Computers

1. Literature collection using INTERNET, search engines, websites, browsing and downloading for scientific investigation.
2. Creating an e-mail account, sending and receiving mails.
3. Application of excel sheet for data processing.
4. Preparation of power point presentation with software.
5. Representation of statistical data by Histograms and Pie diagrams.

(c) Bioinformatics

1. Study of Internet resources in Bioinformatics. E.g. NCBI and EMBL.
2. Searches on MEDLINE and PubMed bibliographic databases.
3. Multiple Sequence Alignment.
4. Construction of Phylogenetic Trees for DNA and Proteins.
5. Sequence Retrieval from Databases.
6. Building of Molecules.
7. BLAST, FASTA programs for sequence database search.

FACULTY OF SCIENCE
M.Sc , ZOOLOGY,
SEMESTER. III
Paper – I
IMMUNOLOGY

UNIT-I: INTRODUCTION TO IMMUNE SYSTEM

- 1.1 cells and tissues of the immune system.
- 1.2 Innate and acquired immunity.
- 1.3 Antibody – Structure, types and functions; Primary and Secondary Ab responses.
- 1.4 Antigen – Antibody reaction – Epitopes and Haptens.

UNIT-II: MATURATION ACTIVATION AND REGULATION OF LYMPHOCYTES

- 2.1 T-cell maturation and differentiation.
- 2.2 T-cell molecular components and structure.
- 2.3 T_H -cell activation mechanism. Cell death and T-cell regulation of immune response.
- 2.4 B-cell receptors B-cell generation, activation, differentiation and proliferation.

UNIT-III: EFFECTOR MECHANISM AND REGULATION OF IMMUNE RESPONSE

- 3.1 Structure of MHC molecules – Class -I and Class-II
MHC in mouse and HLA system in human.
- 3.2 Structure and functions of cytokines.
- 3.3 Cytokine receptors and signaling.
- 3.4 Components of Innate Immune system. NK cells mechanism and action.

UNIT-IV: IMMUNITY IN DEFENCE AND DISEASE

- 4.1 Immunity defense against Bacteria, Viruses, Fungi and Parasites.
- 4.2 Bone marrow Transplantation Immunology. Mechanism of Allograft rejection
Graft -Versus- Host Disease.
- 4.3 General features of Tumour Immunity. Tumour antigens. Immune responses to
Tumours.
- 4.4 Hyper sensitivity, AutoImmunity and Acquired Immuno Deficiency disease

REFERENCE BOOKS

1. ABUL K. ABBAS – CALL AND MOLECULAR IMMUNOLOGY
2. Kuby. Immunology, W.H Freeman, USA
3. W.Pual, Fundamentals of immunology.
4. I.M. Roitt , Essential immunology, ELBS Edition.

FACULTY OF SCIENCE

M. Sc, ZOOLOGY, SEMESTER. III Paper – II

Cell Biology

Unit-I: Introduction to cell biology and Biomembranes.

- 1.1. Discovery of cell, cell theory, prokaryotes and eukaryotes, evolution of eukaryotic cell.
- 1.2. Structural organization of virus, bacteria and eukaryotic cell- ultra structure of animal cell.
- 1.3. Biomembranes: chemical composition and molecular arrangement (lipid bilayer, membrane proteins and carbohydrates), models of membranes(fluid mosaic).
- 1.4. Membrane Transport: Diffusion (simple and facilitated) and active transport (primary and secondary), carrier proteins (uni, sym and antiporters), channel proteins(voltage and ligand gated). Bulk transport-pino, phago and exocytosis. Receptor mediated endocytosis.

Unit-II: Intracellular Compartments and protein sorting

- 2.1. Synthesis of proteins on free and bound ribosomes, signals for protein sorting.
- 2.2. Nucleus: components, nuclear pore complex, organization of chromatin- nucleosomes, chromosomes, export and import of proteins, Mitochondria structure & functions
- 2.3. Endoplasmic reticulum (types): signal peptide hypothesis, insertion of membrane proteins and glycosylation
- 2.4. Golgi (cis and trans): secretory and lysosomal proteins. Glycosylation of proteins.

Unit III: Cell Signalling, cell interactions and cytoskeleton.

- 3.1. Cell surface receptors: G-protein linked receptors, signal transduction, second messengers, receptor tyrosine kinases and intracellular receptors.
- 3.2. Cell junctions: tight junction, desmosome, hemidesmosome and gap junctions.
- 3.3. Cell adhesion molecules: cadherins, Immunoglobulin like molecules, integrins and selectins.
- 3.4. Cytoskeleton: Microtubules, microfilaments and their dynamics. Centrosome, cilia, flagella. Mitotic apparatus and movement of chromosomes.

Unit IV: Cell cycle, apoptosis and cancer

4.1. Phases of cell cycle. Regulation of cell cycle: Discovery of MPF, cyclins and cyclin dependent kinases, Check points- role of Rb and p53.

4.2. Cancer. Types and stages. Tumor suppressor genes and protooncogenes. Molecular basis of cancer.

4.3. Apoptosis. Neurotrophic factors, caspases, Pathways of apoptosis.

4.4. cell senescence, telomerase

PRACTICALS

1. Observation of a Eukaryotic cell under higher microscope.
2. Preparation of mitotic chromosomes from roots tips.
3. Preparation of mitotic Chromosomes from testis of grasshopper.
4. Membrane fragility as a measure of osmotic tolerance
5. Lysosome isolation in isotonic sucroses.
6. Isolation & determination of number of mitochondria
7. Extraction of nuclear Chromatin
8. Extraction of membrane lipids and observation of lipid bilayer formation

REFERENCE

1. Molecular cell biology : Lodish, et al.
2. Molecular cell biology : Bruce Alberts, et al.
3. Cell Biology : DeRobertis.
4. Cell and molecular biology, : Gerard karp
5. Molecular cell biology : David Baltimore.
6. Cell Biology : Sc Rostogi.

FACULTY OF SCIENCE
M.Sc. ZOOLOGY (Final)
III Semester
Paper II
HISTOCHEMISTRY

UNIT – I

1. Scope and importance of Histology and Histochemistry
2. General principles for the preparation of Tissue for Histological studies.
3. Principle for the preparation of tissues for Histochemical localization of various Substrates and Enzymes
4. Fixation – Principle, Aims and Objectives of fixatives. Chemical action of fixatives on cells and tissue components

UNIT – II

1. The Theory of Staining and its importance
2. Histochemical classification of Carbohydrates and Principle for the Identification of Carbohydrates (Periodic acid/Shift method (PAS)
3. Histochemical localization of Mucopoly Saccharides by $KMNO_4$ /AB and PAS method.
4. Histochemical classification of Lipids. Principle for the demonstration of Lipids in various animal tissues (Copperphthalocyanin method and Sudan Blank- B method)

UNIT – III

1. Histochemical classification of Proteins
2. Principles and mechanism for the Identification of Total Proteins and Glycoproteins (Bromophenol Blue & Congo red method)
3. Principle and mechanism for the identification of Amyloids.
4. Histochemical localization of Nuclie Acids, DNA and RNA (Fulgen reaction & Pyrorin –y method).

UNIT – IV

1. Cryostat and Importance of Enzyme histochemistry.
2. Localization of enzymes in tissues, Alkaline and Acid phosphates.
3. Application of Histochemical methods for the detection of various types of Carcinoma and Immunofloroscent techniques.
4. The mountain's and their role.

PRACTICALS

1. Preparation of Reagents and Isolation of Animal Tissues for Histological and Histopathological Studies.
2. Preparation of Histological, Histopathological and Histochemical slides by using various Fixatives.
3. Identification of Carbohydrates and allied chemical substances (Total Carbohydrates, Glycogen, Acid Mucopolysaccharides, Alkaline Mucopolysaccharides , Neutral Mucopolysaccharides) in Animal Tissues.
4. Identification of Proteins and allied chemical substances (Total Proteins, Glyco Proteins, Tyrosin, Tryptophan) in Animal Tissues.
5. Identification of Lipid profile (Total Lipids and Phospho Lipids) in Animal Tissues
6. Identification of Nucleic Acids (DNA & RNA) in Animal Tissues
7. Screening of Cancer slides prepared by Immunofluorescent Study.
8. Demonstration of Enzyme Assay by Cryostat.

References:

1. Histochemistry Theoretical and Applied, A. G. E. Pearse, (1999), Churchill Livingstone, London & New York.
2. Progress in Medical Laboratory Techniques, J.D. Bancroft, (1990) Butterworth Press, London.
3. Histochemistry Theory and Practice, Barka, T and Anderson, P.J (1989) Hoeber New York.
4. Histochemistry in Focus, A source book of Technics and Research needs (2007), K.Shyamasundari and K.Hanmantha Rao, MJP Publishers, Chennai.
5. Cytochemistry, Danielli, J.F. (1999), Wiley & Sons, New York, Chapman and Hall, London.
6. Histochemical Techniques, Cassimann, W.G.B (1988), Methuen, London
7. Enzyme Histochemistry and its Applications in the study of Neoplasms, Burstone, M.S. (1978), Academic Press, New York.
8. An introduction to Functional Histology, Bourne, G.H. (1988), Churchill, London.

FACULTY OF SCIENCE
M.Sc. Zoology
Semester- III
Paper-1V
MOLECULAR BIOLOGY

UNIT- I: Molecular genetics

- 1.1. Concept of gene, genome, C value paradox, organization of prokaryotic and eukaryotic gene, non-coding DNA, transposons; organelle DNA, viral DNA
- 1.2. Genes and enzymes (one gene one enzyme hypothesis)
- 1.3. DNA Replication (in prokaryotes and eukaryotes), repair and recombination
- 1.4. Genome of prokaryotes, vertebrates and human.

UNIT- II: Transcription and Regulation

- 2.1. Types of RNA, secondary and tertiary, structure and function
- 2.2. Transcription in prokaryotes, eukaryotes, RNA polymerases
- 2.3. Post transcriptional modifications-RNA splicing and processing (5' capping, Poly A adenylation), mRNA editing, inhibitors of transcription, reverse transcription, Mitochondrial translation.
- 2.4. Regulation of gene expression(Operon, arabinose, tryptophan models)

UNIT- III: Translation and Regulation

- 3.1. Ribosome structure, Genetic code (codon anticodon recognition, wobble hypothesis, mutations)
- 3.2. Polypeptide synthesis (initiation, elongation, termination), control of eukaryotic translation, Effect of antibiotics on protein synthesis
- 3.3. Post translational modifications, protein folding, protein sorting
- 3.4. Mitochondrial translation, proteomics and proteomic analysis

UNIT- IV: Molecular techniques

- 4.1. Isolation and purification of RNA, DNA (genomic and plasmid) and proteins; their analysis by one and two dimensional gel electrophoresis, isoelectro focusing gels.
- 4.2. Blotting techniques – Southern (DNA), Northern (RNA), Dot blotting and Western (proteins).
- 4.3. Protein and DNA sequencing methods, strategies of genome sequencing, microarrays
- 4.4. DNA fingerprinting, PCR principle, DNA polymerases RFLP, RAPD and AFLP techniques

PRACTICALS

1. Isolation of DNA from goat spleen
2. Estimation of DNA (diphenyl method)
3. Estimation of RNA (Orcinol method)
4. UV absorption spectra of native and denatured DNA
5. Agarose gel Electrophoresis of DNA
6. DNA amplification by PCR
7. Gel Documentation

REFERENCE BOOKS

1. Molecular Cell Biology by Lodish et al
2. Molecular Cell Biology by Alberts et al
3. Principles of Biochemistry by Lehninger
4. The Cell by Geoffrey Cooper
5. Genetics , A molecular approach by Peter J Russell
6. Biochemistry by Voet and Voet
7. Principles of Genetics by Tamarin
8. GENES VIII by Lewin
9. Biochemistry by U.Satyanarayana and U Chakrapani

**FACULTY OF SCIENCE
M.Sc. ZOOLOGY,
SEMESTER - IV
PAPER – I**

ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY

UNIT-I : ENDOCRINE GLANDS

- 1.1 Endocrine glands, their hormones and classification of hormones
- 1.2 Bio synthesis, storage and mechanism of hormonal action.
- 1.3 Hormonal receptors and mechanism of hormonal action.
- 1.4 Hormonal regulation of Carbohydrates , Lipids and endocrine disruptors.

UNIT-II : REPRODUCTION

- 2.1 Spermatogenesis and its hormonal regulation.
- 2.2 Accessory reproductive organs (glands) and semen composition.
- 2.3 Sexual cycles , oogenesis and their hormonal regulation.
- 2.4 Fertilization , implantation ,gastrulation, Parturition, lactation and structure and function of mammary glands.

UNIT – III : REPRODUCTIVE BIOTECHNOLOGY

- 3.1 Assisted reproductive techniques and teratogenesis
- 3.2 Transgenic animals and gene knock outs.
- 3.3 Sexually transmitted diseases, symptoms pathogenesis and prevention.
- 3.4 Ageing and reproduction.

UNIT –IV : DESIGNING EXPERIMENTS FOR THE STUDY OF BREEDING AND FERTILITY

- 4.1 Care and breeding techniques of laboratory animal (rats & rabbits)
- 4.2 Surgical techniques in the study of mammalian reproduction.
- 4.3 Techniques in radio-immunoassay, enzyme immunoassay and radio receptor assay.
- 4.4 Use of monoclonal and polyclonal antibodies in the study of reproduction

PRACTICALS

1. Histological slides pertaining to endocrine glands.
2. Alloxan diabetes induction and insulinization study by blood glucose and liver glycogen estimation.
3. Effect of thyroids and antithyroidal agents on O_2 Consumption in the rat./ crab
4. Effect of oxytocin on uterine contractility.
5. Estrogen bioassay using immature female rats / mice.
6. Study of male and female reproductive systems in some reproductive animals.
7. Histology of ovary and testes.
8. Study of estrus cycle (Rat).
9. Diagnosis of pregnancy by the presence of HCG in urine (Acheim Zondek test)
10. Sperm morphology, motility, count and effect of some antifertility agents.
11. Models pertaining to ART(Assisted reproductive techniques), Transgenic techniques. STDs contraception, teratogenesis.
12. Visit to Veterinary Institutes to learn breeding techniques.

REFERENCE BOOKS

1. E.J.W. Barington , General and comparative Endocrinology.
2. P.J.Bentley , Comparative Vertebrate Endocrinology.
3. R.H. Williams, Text book of Endocrinology.
4. A.Gorbman *et.al.*, Comparative Endocrinology.
5. Austen,C.R. and Short R.V. Reproduction
6. R.G.Edwards, Human Reproduction
7. E. Knobil and J.D Neill, The physiology of Reproduction volume I & II
8. E.S.E .Hafeez, Reproduction and breeding techniques for laboratory animals
9. Vander and Sherman, Human Physiology.
10. Kamini A.Rao, The infertility manual
11. A.V.Nalbondov, Reproduction Physiology.
12. K.Murray and K. Granner, Harper Biochemistry
13. J.Farris and John Griffith, The rat in laboratory investigation.
14. R.Mathur and S.Shukla ,Reproductive Biology.
15. B.P.Setchell, The mammalian testis.
16. S.F.Gilbert, Developmental Biology.
17. Vinod K. Sharma., Sexually Transmitted Diseases and ADIS
18. Gayathri Prakash, Reproductive Biology.

**FACULTY OF SCIENCE
M.Sc. ZOOLOGY.
SEMESTER – IV
PAPER-II**

DEVELOPMENTAL BIOLOGY

UNIT-I: Principles of Development in Biology

- 1.1 Introduction to Developmental Biology: The Stages of Animal Development, Embryonic Homologies, Malformations and Teratology.
- 1.2 Developmental Patterns in Unicellular Protists and Metazoa.
- 1.3 The Developmental Mechanics of Cell Specification.
- 1.4 Determining the Function of Genes during Development.

UNIT-II: Early Embryonic Development

- 2.1 Introduction to Embryonic Development: Structure of Gametes, Recognition of Egg and Sperm, Acrosomal Reaction.
- 2.2 The Early Development of Snails.
- 2.3 The genetics of axis specification in *Drosophila*.
- 2.4 Early Mammalian Development: Mammalian Anterior-Posterior Axis Formation, Dorsal-Ventral and left-Right Axes in Mammals.

UNIT-III: Later Embryonic Development

- 3.1 Tetrapod limb Development.
- 3.2 Sex Determination approaches in Developmental Biology.
- 3.3 Metamorphosis, Regeneration and Aging.
- 3.4 The Development of Blood Cells: The Stem Cell concept, the pluripotential hematopoietic stem cells, Blood and lymphocyte lineages, hematopoiesis.

UNIT-IV: Ramifications of Developmental Biology

- 4.1 Environmental regulation of animal development.
- 4.2 Hox Genes: Descent with Modification.
- 4.3 Homologous Pathways of Development.
- 4.4 Teratogenesis: Introduction, Principles and Teratogenic agents.

DEVELOPMENTAL BIOLOGY (PRACTICAL SYLLABUS)

1. Observation of living Chick embryo.
2. Dissection and Morphology observation of the 4-14 somite chick embryo (24-34 hours).
3. Dissection and Morphology observation of the 24-38 somite chick embryo (48-85 hours).
4. Culture of Early chick embryo *in vitro*.
5. Mounting of 72 and 96 hours chick embryo.
6. Chorio-Allantoic Membrane Grafting.
7. Various patterns of Cleavage and development in freshwater Snail.
8. Larval Developmental stages of Drosophila.
9. Chromosome squash preparation from Drosophila larval salivary glands.
10. Patterns of regeneration in the Planarian/Regeneration in the Tail of Frog Tadpoles.

Reference Books:

1. Gilbert, S.F. Developmental Biology. 10th Edition, Sinauer Associated Inc., Massachusetts
2. Balinsky, B.I. Introduction to Embryology. Saunders, Philadelphia
3. Berril, N.J. and Karp, G. Development Biology. McGraw Hill, New York
4. Hamburger V and Hamilton HL. Handbook of chick developmental stages. Saunders Publications. 1965.
5. Berril, N.J. and Karp, G. Development Biology. McGraw Hill, New York
6. Embryology-An Introduction to Developmental Biology—Stanley Shostak
7. Muthukaruppan and Pitchappan. Animal development – a laboratory guide. CoSIP-ULP Publications, India. First Edition, 1979.

FACULTY OF SCIENCE
M.Sc. ZOOLOGY.
SEMESTER – IV
PAPER-III

ANIMAL BIOTECHNOLOGY

UNIT-I: Basics of Animal Biotechnology

- 1.1 History and Scope of Animal Biotechnology; Current status and Future Applications of Animal Biotechnology.
- 1.2 History and Scope of Animal Cell Culture; Types of Cell Culture.
- 1.3 Laboratory facilities for Animal Cell Culture; Culture Media and Culture Procedures.
- 1.4 Stem Cells: Definition and Meaning of Stem Cells; Functions and origins of Stem Cells; Types of Stem Cells; Stem Cell Therapy.

UNIT-II: Applied Animal Biotechnology

- 2.1 Concepts of r-DNA Technology; Genetic Engineering through Plasmids, Cosmids and Lambda phages.
- 2.2 Animal Cloning Methods and Utility; Transfection Methods and Transgenic Animals.
- 2.3 Biosensors: History of the Development of Biosensors; Working Principle and Protein Engineering for Biosensors; Applications of Biosensors.
- 2.4 Nucleic acid Hybridization; Establishment and importance of Gene Banks; Construction of Genomic libraries and DNA libraries.

UNIT-III: Pharmaceutical Animal Biotechnology

- 3.1 Introduction to Pharmaceutical Biotechnology; Basics on Products of Pharmaceutical Biotechnology (Lymphokines, Interferon's, Human Growth Hormone and Insulin).
- 3.2 Genetic Engineering for the production of Insulin.
- 3.3 Production and Applications of Monoclonal Antibodies (MAbs).
- 3.4 Vaccines: Preparation and role of Genetic Engineering in the production of Vaccines.

UNIT-IV: Medical Animal Biotechnology

- 4.1 Animal and Human Health Care: Diagnosis and Treatment of Diseases; Genetic Counseling; Forensic Medicine (DNA Finger Printing).
- 4.2 Gene Therapy: Human Diseases Targeted for Gene Therapy; Vectors and other Delivery systems for Gene Therapy.
- 4.3 Gene Therapy for Genetical and Acquired Diseases; Gene therapy using Nanotechnology.
- 4.4 Intellectual Property Rights: Introduction to Intellectual Property; Types of IP; Patents, Trademarks, Copyright & Related Rights, Protection of GMOs; IPs of relevance to Biotechnology; Types of patent application.

PRACTICALS

1. Laboratory demonstration on safe handling of microorganisms.
2. Isolation of plasmid DNA from E-Coli .
3. Isolation of yeast DNA and Transformation of E-Coli.
4. Qualitative assay of B.Galactosidase in yeast Colonies/cell extracts.
5. Propagation & maintenance of tissue culture.
6. Isolation of Bone marrow and culture of mesenc hymel stem cells from isoleted murine/sleep/rat bone marrow.
7. Try pan blue exclusion method for cell viability estimation.
8. Mycoplasma detection method using PCR.
9. Production of penicillin and testing of antimicrobial activity.
10. Production of monoclonal of tissue culture.

REFERENCE BOOKS.

1. Culture of Animal cells – manual of basic Technique by R. Iam Freshney published by
2. Molecular Biotechnology by john Wiley & Sons Primrose Published by parima publishing corporation.
3. Principles and practice of Animal tissue culture by Sudha Gangal Published by University Pren
4. Laboratory procedures in Biotechnology--- Alam Doyle ,J.Bryan Griffiths.wiley publisher
5. Animal Biotechnology- A Laboratory course, --- Jeddrey M.Beeker. Elsevien IInd edition,2007.
6. Tools & Techniques in Biotechnology – Mousami Debnath, pointer publishers,2002
7. Principles & techniques of Biotechnology & Muecular Biology-- 6th edition, keith Wilson& John Walker
8. Gene cloning & manipulation, Christopher howe, Combridge Publications.
9. A manual of Laboratory Practices. Good

FACULTY OF SCIENCE
M.Sc. ZOOLOGY (Final)
IV Semester
Paper IV
FISHERIES AND AQUACULTURE

UNIT – I

1. Introduction, Definition, Scope, and Importance of Fisheries
2. Origin and Evolution of Teleost Fishes.
3. Classification and general characters of Fishes up to Sub-class.
4. Taxonomic identification of Fresh Water fishes by the Morphometric Method.

UNIT – II

1. Origin and Classification of Fresh water bodies – Rivers, Lakes and Ponds.
2. Ecology of Lentic and Lotic water bodies.
3. Physico- Chemical (Temperature, Light, Hardness, pH, Chlorides, Dissolved Oxygen Alkalinity and Acidity) and Biological characteristics of water bodies
4. Productivity of water bodies and its importance.

UNIT – III

1. Structure and Management of Culture ponds, types of Fish seed
2. Mono culture, Polyculture and Composite fish culture.
3. Integrated Aquaculture and its relevance.
4. Plankton and its significance in Aquaculture

UNIT – IV

1. Determination of Health Condition in Fishes and Ectoparasites of Fishes
2. Helminthes parasites of fishes and their pathogenicity
3. Protozoan diseases of fishes and their pathogenicity
4. Bacterial and Fungal diseases of fishes and their pathogenicity .

PRACTICALS

1. Visit to local Fresh water bodies to study their Ecology.
2. Collection, Identification and Screening of fish for Ecto and Endo parasites
3. Morphometric and Meristic data of Fishes (At least 3 types).
4. Estimation of Productivity of local Fresh water bodies.
5. Collection and preservation of Water and Soil from water bodies.
6. Collection, Preservation and Identification of plankton.
7. Estimation of P^H, Temperature, Chlorides, Dissolved Oxygen from water samples.
8. Estimation of Organic matter of bottom soil.
9. Visit to local fish seed production centre.
10. Visit to local fish farms.

References:

1. Business Management in Fisheries and Aquaculture, Fishing News, Chaston, I (Books) Ltd., 1984.
2. Aquaculture Management, Meade, J.W. Van Nostrand, New York, 1989.
3. Aquaculture principles and practices, Pillay, T.V. R. Fishes News (Books) Ltd., London, 1990.
4. Water Quality Management for Pond Fish culture, Boyd, C.E. Elsevier Scientific publishing company, 1982.
5. Principles of Fresh Water Aquaculture, Stickney, R.R. John, Wiley & Sons, New York, 1979
6. Aquaculture – The Farming and Husbandry of fresh water and marine organisms, Bardach, et al., John Wiley & Sons, New York, 1979.
7. A manual of Freshwater Aquaculture, Santhanan, R. et al., Oxford & IBH Publishing Co. Pvt. Ltd., 1987.
8. Advances in Aquaculture, Pillay, T.V.R. & M.A., DIII. Fish News (Books) Ltd., England, 1979.
9. Limnology, Welch, P.S, Mc. Grew Hill, New York, 1952.
10. Text book of Limnology, Cole, C.A., The C.V. Mosby Co., 1983.
11. Fundamentals of Limnology, Ruttner, F, Translated by D.G. Frey and F.E. Fry, University of Toronto Press, 1968.
12. The Fresh Water Fishes of India, Pakistan, Bangladesh, Burma and Sri Lanka, Hand Book , Jayaram , K.C., (1981), Zoological survey of India, Calcutta.
13. Fishes, An Introduction of Ichthyology, Moyle Peterb, Prentice Hall, (1979).

14. Principles of Systematic Zoology, Mayer and Ashok..
15. Fish and Fisheries of India, Jhingran, V.G. Hindustan Publishing Co., Calcutta, (1975).
16. Fish and Fisheries, Yadav, B.N. Daya Publishing House,
17. The Biology of Animal Parasites, Chang. T.C. Saunders, Philadelphia, (1964).
18. Text book of Fish Diseases. Conroy. D.A. and R.C. Heanean, (1968).
19. Fish Diseases Vol. I & II, Schaperclaus,
20. Methods for assessment of Fish Production in Fresh Water, Ricker, W.K. (1984), Blackwell Publications.

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