

## M. Sc. (Zoology) Semester I

### Paper – I Microbiology

#### Section – A

- **Introduction to Microbiology:** History and importance of microbiology, Introduction to the classification of microorganisms (Bacteria, Virus)
- **Kinds of Microorganisms:** Animal and plant viruses, Bacteriophages, Rickettsiae, Bacteria, Mycoplasma, Fungi, Slime moulds etc
- **Microorganisms in their natural habitat:** Atmosphere, Hydrosphere, Lithosphere & Extreme habitats. Microbial interaction (Symbiotic and asymbiotic)
- **Microbial morphology and physiology:** Bacteria (typical structure and classification, chemical composition, nutrition, locomotion, reproduction and culture) and Colicins
- **Microbial media & culture techniques:** Development of pure culture methods, Enrichment culture methods, Principles of microbial nutrition, Theory and practice of sterilization, Construction of culture media, Culture collection and maintenance of cultures
- **Microbial Growth:** Mathematical expression of growth, growth curve, Measurement of growth and growth yields, Synchronous growth, Growth as affected by environmental factors like temperature, acidity, pH, water availability and oxygen

#### Section – B

- **Viruses:** Structure and composition, classification, physical properties and viral action, isolation, culture and purification of viruses, Viroids & Prions, RNA & DNA viruses, Lytic and Lysogenic cycles. Production of vaccines
- **Microbiology of Water:** Types of water, Microorganisms of water, Microbiology of potable water, Purification of water, Microbiology of sewage, Bioremediation
- **Microbiology of Soil:** Microorganisms of soil, Factor affecting microbial community in soil, microorganisms associated with organic matter decomposition, Rhizosphere microorganisms, Cycles of elements (Carbon, Sulphur and Nitrogen)
- **Microbiology of Air (Aero microbiology):** Distribution of microorganisms in air, Aeroallergens, collection and enumeration of aerial microorganisms
- **Microbiology of food:** Microbial contamination and spoilage of industrial and domestic food, sources of food poisoning, some fermented foods, preservation of foods
- **Antibiotics:** History of Penicillin, Classification of Antibiotics, Non-medical uses of antibiotics, Biological action of antibiotics
- **Microbial Diseases & Disease reservoirs:** Epidemiological terminologies, Infectious disease transmission, Sexually transmitted diseases including AIDS, Food, water and air borne microbial diseases, Diseases transmitted by animals (rabies, plague), Bacteria & viruses as pathogens in aquaculture
- **Biohydrometallurgy:** History of bioleaching, Microbiology of leaching of Sulfide minerals, Applications of bioleaching techniques

## Paper II – Non-Chordata

### Section – A

**General classification,** habit and habitats, characters, of Non-Chordate Phyla:

**Protozoa:** Nutrition (Holophytic, Holozoic, Saprophytic, Myxotrophic and Parasitic), Locomotion (Locomotory organelles, and types of locomotion), Reproduction (Asexual, Sexual reproduction and Parthenogenesis)  
Life- cycle of *Trypanosoma*

**Porifera:** Canal system, Reproduction (Asexual, Sexual Reproduction and Parthenogenesis) and Phylogeny

**Coelenterata:** Polymorphism  
Corals and coral reefs  
Structure and affinities of Ctenophora

**Helminthes:** Life-cycle of *Wuchereria* and *Schistosoma*  
Parasitic adaptations

**Minor Phyla:** Organization and Affinities of Rotifera and Brachiopoda

### Section – B

**Annelida:** Segmental Organs  
Adaptive Radiations in Polychaeta

**Arthropoda:** Larval forms in Crustacea  
Mouth parts in Insects  
Social-life in Honey-Bees and Termites  
Onychophora: Organization and Affinities

**Mollusca:** Major features of Respiratory and Reproductive Systems  
Torsion  
Pearl formation

**Echinodermata:** Water Vascular System  
Larval forms

## Paper III – Ecology

### Section – A

**Ecology:** Its relevance to human welfare, subdivisions and scope. The Environment: physical environment; biotic environment; biotic and abiotic interactions, ecosystem diversity, ecosystem services

**Habitat and Niche:** Concept of habitat and niche; niche width and overlap; fundamental and realised niche; resource partitioning; character displacement

**Ecosystem's structure and function:** Abiotic and biotic components of aquatic (Lake) and Terrestrial (forest) ecosystems, primary and secondary productivity, movement of energy and materials, energy efficiency, thermal stratification and circulation in lake, Lake's typology

**Limiting factors:** Laws of limiting factors, impact of temperature, moisture and pH on organisms

**Population Ecology:** Characteristics of a population; population growth curves, population regulation; life history strategies ( r and K selection); concept of meta-population-demes and dispersal, interdemec extinctions, age structured

**Community Ecology:** Community nomenclature, completion, community attributes namely dominance, various types of diversity indices, similarity coefficient, ecotone and edge effect

**Ecological Succession:** Types; mechanisms, changes involved in succession, concept of climax

### Section – B

**Stressed ecosystems:** Point and non-point sources of pollution, assessment of freshwater pollution using various parameters; Water quality monitoring using abiotic factors (e.g. pH, oxygen, nitrate, ammonia, phosphate, BOD), bio monitoring (phytoplankton, zooplankton and zoo benthos), Environmental Impact Assessment (EIA)-impact of environmental stress on biotic and abiotic factors

**Eutrophication:** Its causes, assessment, consequences and control; Indicators of pollution and eutrophication

**Global Environmental Problems:** Climate change, Global warming, acid rains, greenhouse effects, ozone layer depletion

**Biodiversity:** Status, monitoring and documentation; major drivers of biodiversity change; biodiversity conservation and management, project tiger, biosphere reserves

**Conservation Ecology:** Principles of conservation, major approaches to management, Indian case studies on conservation and management programs (National Lake Conservation Program; “Namami Gange Pariyojana” and Ganga Action Plan); theory of island biogeography

## **Paper IV – Taxonomy and Evolutionary Biology**

### **Section – A**

**Introduction to Systematics and Taxonomy:** Significance and brief History of Taxonomy

**Modern:** approaches in Taxonomy

**Concepts of Zoological classification:** functions, systems of classification, Linear hierarchy, Taxonomic Aids (Museums, National Parks, and Keys)

**Species Concept:** Typological, Nominalistic, Biological and Evolutionary

**Rules of Zoological Nomenclature:** International Commission on Zoological Nomenclature (ICZN), Taxon, Rank and Categories

**Collection,** Preservation and Identification of insects and other specimens using Keys

### **Section – B**

**Modern Synthetic Theory:** Genetic variability in populations, Significance of Genetic Variability, Natural Selection. Genetic Drifts, Isolation, Origin of New Species

**Variations:** Nature of Variations, Kinds of Variations (Meristic and Substantive, Continuous and Discontinuous, Determinate and Indeterminate, Somatic and Germinal, Polymorphic, Cryptic and Geographical Variations), Sources of Variations (Environment, Endocrine Glands), Cytological Basis of Variations (Gene mutations, Chromosomal mutations, Changes in Chromosomal number, Sexual Recombination, Recombination due to exchange of genes between Chromosomes, Hybridization)

**The Origin of Species:** Concepts of Species, categories of species (Demes, Geographical Races, Ecological Races, Climes), Types of Species (Sibling species, Monotypic and Polytypic species)

**Speciation:** Phyletic Speciation, Quantum Speciation, Gradual Speciation (Allopatric, Sympatric, Parapatric)

**Basic Patterns of Evolution:** Microevolution, Macroevolution and Mega evolution, Mechanisms of evolution, Essential features of Macroevolution and Mega evolution

**Mimicry and Protective Coloration:** Kinds of Mimicry (Protective Mimicry, Aggressive, Batesian and Mullerian), Significance of Mimicry; Coloration (Colour Production, Biological Significance of Coloration)

# Paper V – Molecular Biology

## Section – A

- **Introduction to Molecular Biology:** Structure and organization of genome. Law of DNA constancy,  $C_0t$  curve (cot curve), c-value paradox, DNA renaturation kinetics, Determination of  $T_m$  value
- **Chemistry of gene:** Structure of nucleic acids (A, B, C and Z-DNAs, RL-model of Sasisekharan; supercoiling; genetic and non-genetic RNAs)
- **DNA as genetic material:** DNA Replication - (evidence for semi conservative replication); Prokaryotic and eukaryotic DNA replication, Molecular Mechanisms of DNA replication, Enzymes and accessory Proteins involved in DNA replication. DNA repair (excision repair, mismatch repair and SOS repair), DNA repair and genetic disease in humans and Recombination, Homologous Recombination, Holliday junction, FLP/FRT and Cre/Lox recombination, RecA proteins and recombinases
- **Fine structure of gene:** organization of typical eukaryotic gene, Benzer's analysis of r-II locus by deletion and complementation mapping; General introduction to complexities of gene regulation in eukaryotes, Regulation of Gene expression in Prokaryotes and Eukaryotes: Operon concept (*E. coli* lac operon, trp operon, ara operon), DNA methylation, Heterochromatinization, Environmental regulation of gene expression

## Section – B

- **Mutation:** Chromosomal aberrations (Numerical and Structural), Gene mutation: different types of mutations, mutagens, Detection of sex linked lethal and visible mutations in *Drosophila*
- **Transcription:** Prokaryotic and Eukaryotic transcription, RNA polymerase, General and specific transcription factors, transcription signals, promoter sites, rho and sigma factor, Regulatory elements and mechanisms of transcription regulation, Transcriptional and post-transcriptional modifications, Reverse transcriptase, RNA processing, Modifications in RNA: 5'-Cap formation, Transcription termination, 3'-end processing and polyadenylation, Splicing, Ribonucleoproteins, RNA editing, Nuclear export of mRNA and stability
- **Translation:** Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co- and post-translational modifications of proteins. Genetic code: Properties, codon usage patterns and codon bias (Wobble Hypothesis), new genetic codes in mitochondria and ciliate protozoa
- **Nucleic acid sequencing:** Introduction and landmarks in DNA sequencing, Maxam Gilbert method, Sanger's method, introduction to automated DNA sequencing, Pyro sequencing, Nextgen sequencing, Whole genome sequencing. Antisense and Ribozyme Technology- Molecular mechanism of antisense molecules, Biochemistry of ribozyme; hammer- head, hairpin and other ribozymes, strategies for designing ribozymes, Applications of antisense and ribozyme technologies

## M. Sc. (Zoology)

### I<sup>st</sup> Semester Practical

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session.

The practical work shall comprise:

1. Study of permanent prepared slides of different Phyla
2. Study of the museum specimens belonging to the different invertebrate Phyla
3. Permanent preparations of the material available/provided
4. **Experiments on Ecology:**
  - (a) Calculation of similarity index between different communities
  - (b) Calculation of concentration of dominance for different communities
  - (c) Calculation of Shannon Weiner Index of diversity in different communities
  - (d) Determination of salinity and chlorinity in water samples
  - (e) Determination of moisture content and total organic matter in soil sample
  - (f) Determination of dissolved oxygen
  - (g) Determination of free CO<sub>2</sub> in water sample
  - (h) Determination of the thermal stratification and circulation period of a water body

Note: for (a, b, c, and h) data is to be provided

5. **Microbiology:**

- (a) Preparation of culture media for bacteria
- (b) Staining of microorganisms
- (c) Antibiotic sensitivity test
- (d) Bacteriological testing of milk
- (e) Isolation and characterization of intestinal pathogens

6. **Parasitology:** Study of life-cycle of some parasites through charts, models or live materials

7. **Evolutionary Biology and Systematics:**

- (a) Study of evolution of horse, elephant, and man( through charts/ models)
- (b) Adaptive modification in feet of birds/mouthparts of Insects (through charts/ slides)
- (c) Embryological evidences of evolution (through chart)
- (d) Analogy and Homology (wings of birds and insects, forelimbs of bats and rabbits through charts)
- (e) Identification of local fauna on the basis of their morphological characters (5 each)

- (f) Construction of a dichotomous key
- (g) Zoological names of some local fauna
- (h) Taxonomy of *Drosophila* (Chaetotaxy)

➤ **Following Practical's can also be conducted subject to the availability of infrastructure**

- Preparation of liquid and solid media for growth of microorganisms
- Isolation and maintenance of organisms by plating, streaking and serial dilution methods
- Slants and stab cultures
- Isolation of pure cultures from soil and water
- Study of growth curve
- Measurement of bacterial population by turbidometry and serial dilution methods
- Microscopic examination of bacteria, study of organisms by Gram stain, Acid fast stain
- Study of mutations by Ames test
- Assay of antibiotics and demonstration of antibiotic resistance
- UV-Visible spectroscopy
- Titration curves of amino acids
- Paper chromatography
- Colorimetric determination of pK
- Qualitative Analysis of amino acids, sugars and lipids
- Analysis of oils-iodine number
- Separation techniques- Centrifugation
- Estimation of protein content by Lowry's & Burette method
- Estimation of DNA content in the given sample by diphenylamine method
- Estimation of RNA content by the Orcinol method
- Isolation and estimation of casein from milk
- Introduction to measurements: balances and pipetting
- pH meter: buffering capacity of a buffer
- Microscopy
- Microtomy
- Electron microscopy : Demonstration and good photographs for interpretation
- Mitosis & Meiosis
- Séparation techniques (HPLC online demo)
- Preparation of Polytene chromosome

**M. Sc. (Zoology) Semester II**  
**Paper – I Concepts in Cell Biology and Genetics**

**Section – A**

- **Diversity of cell size**, type and shape, Cell theory. Structure of Prokaryotic and Eukaryotic cells. Cellular organelles: Plasma membrane, cell wall and their structural organization; Mitochondria, Chloroplast; Nucleus ER, Golgi complex and microbodies , Nuclear Pore complex. Organization of cytoskeleton; cell microtubules, micro filament and intermediate filaments
- **Molecular aspects of cell division**; Cell cycle - molecular events and model system, cell cycle regulation. Structure and Organisation of membranes, Glycoconjugates & Proteins in membrane system, Protein Localization, Import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis Transport of nutrients, ions and macromolecules across membranes, Passive and active transport,  $\text{Na}^+/\text{K}^+$  pump
- **Cellular communication**: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation
- **Cellular responses to environmental signals in bacteria and animals**: mechanisms of signal transduction; Endocrine, Exocrine & Synaptic signaling, Surface and intracellular receptors, G Proteins & generation of second messengers, mode of action of cAMP &  $\text{Ca}^{++}$ Calmodulin, signal transduction pathways, regulation of signaling pathways

**Section – B**

- **Biology of cancer**: Oncogenes and Tumor Suppressor Genes, Viral and cellular oncogenes, tumor suppressor genes from humans, Structure, function and mechanism of pRB and p53 tumor suppressor proteins, Apoptosis and necrosis
- **Chromosomal analysis**, Banding techniques, Sex-chromatin techniques, Autoradiography, Chromosomes: Structure, chemical composition, classification, folded fibre model and nucleosome model, karyotype, euchromatin and heterochromatin, Giant chromosomes, B-chromosomes
- **Chromosome mapping**: Chromosome mapping in Drosophila (single and double crossing over), human chromosomes (Somatic cell genetics) Mutation: Type and mechanism and effects
- **Concept of gene**: Allele, multiple alleles, isoallele, pseudoallele
- **Mendelian genetics**: Dominance, segregation, independent assortment, Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and crossing over. Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes
- **Microbial genetics**: Methods of genetic transfers – conjugation ( $\text{F}^+$ ,  $\text{F}^-$  and HFR strain), transformation, transduction (generalized and specialized transduction) and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes
- **Plasmids**, IS Elements, Transposons and Retro-Elements: Plasmids, inversion sequences of IS-elements, Transposons and controlling elements in prokaryotes and eukaryotes



## Paper – II Mammalian Endocrinology

### Section – A

- **Brief history** and scope of endocrinology
- **A brief knowledge of environmental endocrinology**
- **Chemical nature, classification and** mode of secretion of hormones, hormonal feedback in homeostasis
- **Mechanisms of hormone action:** Complete knowledge of the generalized mechanisms of action (at molecular level) of protein (Plasma membrane mediated actions as well as intracellular CAMP mediated actions) and steroid hormones (nuclear activity mediated actions)
- **Hypothalamo-hypophysial System:** General organization, Neuro-hypophysial octapeptides, Adeno-hypophysial hormones, Detailed structure of mammalian Pituitary gland and synthesis, storage, control of release, transport, denaturation, physiological actions, morphological and chemical consequences of excess and deficiency of various pituitary hormones
- **Endocrine Pancreas:** Detailed structure, Biosynthesis and physiological actions of insulin and glucagon

### Section – B

- **Thyroid Gland:** Detailed structure, biosynthesis of thyroid hormones, control of secretion, transport, denaturation, physiological roles, morphological and chemical consequences of excess and deficiency of various thyroid hormones
- **Parathyroid Gland:** Synthesis of parathyroid hormones, Role of parathormone, Calcitonin and vitamin-D in calcium homeostasis
- **Adrenal gland:** Adrenal Cortex: Detailed structure, Organization, physiological roles and control of mineralocorticoides and glucocorticoids secretion. Adrenal Medulla: detailed structure, Catecholamine, biosynthesis, release and its physiological roles
- **Pineal gland:** Detailed structure, physiological actions of pineal hormone
- **Reproductive endocrinology:** Molecular structure, origin, release and transport of sex hormones and their role in reproductive physiology (Hormonal regulation of Oestrus and Menstrual cycle and that of lactation)

## Paper – III Biochemistry

### Section – A

- **The molecular logic of life:** Buffering in biological Systems; pH, pK, acids, bases, buffers, Handerson – Hassel Bach equation, weak bonds (Ionic, Hydrogen, Hydrophobic, Vander Waal interactions), covalent bonds, Water as a universal solvent
- **Molecular properties:** Basic concept and significance of diffusion, Osmosis, Gibb's Donnan equilibrium, Viscosity, Surface tension and Colloidal state
- **Bioenergetics:** Thermodynamic laws as applied to biological system, applications of free energy functions, High energy compounds with special reference to ATP, Biological oxidation-reduction reactions; Electron transport and Oxidative Phosphorylation
- **Biomolecules:** Classification, chemical structure, and sources of biochemically significant carbohydrates, proteins and lipids: Amino acids and their classification, Peptide synthesis, Protein sequencing, Functional diversity, Structure and conformation of proteins (protein structural hierarchy, Ramachandran plot, domains, motif and folds)
- **Enzymes:** Nomenclature and classification, kinetics, mechanism of enzyme action, factors influencing enzyme activity Isozymes
- **Coenzymes:** Chemical structure and significance of coenzymes

### Section – B

- **Metabolism of carbohydrates:** Basic concepts of glycolysis and TCA cycle, Glycogenesis, Glycogenolysis, gluconeogenesis, and the pentose phosphate pathway
- **Metabolism of proteins:** Basic concept of protein metabolism with reference to decarboxylation, transamination, transmethylation and deamination of essential and non-essential amino acids, Biosynthesis of urea, creatine and heme
- **Metabolism of lipids:** Basic concepts of lipids metabolism with reference to biosynthesis and utilization of fatty acids of lipids, Significance of ketone bodies and cholesterol
- **Integration of metabolism & concept of metabolic regulations,** General introduction to metabolic disorders, **Vitamins:** Chemical structure, sources and deficiency state of fat soluble and water soluble vitamins
- **Minerals:** Sources and biochemical significance of minerals e.g. Sodium, Potassium, Calcium, Magnesium, Iron, Chloride, Zinc, Phosphorus and Selenium
- **Basic concept of xenobiotic** compounds and their metabolism. (Phase 1 and phase 2 reactions with examples)

## Paper IV – Animal Physiology

### Section – A

**Nutrition:** Stimulation, secretion and action of digestive fluids (including enzymes and hormones), Digestion, absorption and assimilation of various food stuffs

**Respiration:** Respiratory surfaces in different groups and gaseous exchange, Respiratory pigments, Transport of Oxygen and Carbon dioxide, Control of respiratory activity, Respiratory insufficiency

**Circulation:** Haemopoiesis, Heart beat and its regulation, Electro-cardiogram, Hemodynamic and cardiac output, Blood flow through arteries, veins and capillaries (pulse and blood pressure) including regulation, coronary circulation and coronary occlusion

**Muscle physiology:** Structure, kinds and characteristics of muscles, Mechanism of muscle stimulation and contraction

**Thermoregulation:** Temperature tolerance, Poikilothermy, Homoeothermic adaptations and regulatory mechanisms

### Section – B

**Excretion and osmoregulation:** Functions of kidney, Types of nitrogenous wastes in different animal groups and their excretion, renal excretion in vertebrates (urine formation in a mammal in particular), osmoregulation in fish, reptiles, aves and mammals

**Sensory Physiology:** Receptors, Pathways and physiology of smell and taste

**Nervous Coordination:** Structure of neuron, nature, origin and propagation of nerve impulse, Synaptic transmission, Chemistry and functions of neurotransmitters

**Immune System:** Immunity: Types of Immunity (Natural Immunity, Acquired Immunity: Active Immunity, Humoral Immunity, Cell mediated immunity), Antigens and Antibodies, Types of Immunoglobulins, Lymphocytes and Lymphatic System ((T-Lymphocytes and B-lymphocytes, Immunological function of Thymus), Antigen-Antibody Interaction (kinds of Antibodies Induction of Immune Response, Site of Antigen Trapping), Synthesis of Antibodies (Primary and Secondary Responses), Clonal Selection, Transplantation Immunity, (Types of Grafts, Allograft Reaction, Prevention of Rejection, Immunosuppression, Auto immunity) Allergy, AIDS

**M. Sc. (Zoology)**  
**II<sup>nd</sup> Semester Practical**

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session.

The practical work shall comprise:

**1. Experiments on Physiology and Bio-chemistry:**

- (a) Chemical test of urine for the presence of urea, sugar, proteins and ketone bodies
- (b) Tests for carbohydrates, proteins and lipids
- (c) Action of Amylase on its respective substrates
- (d) Determination of Haemoglobin (gm %) in human blood; also calculation of colour index and the mean corpuscular haemoglobin concentration
- (e) Estimation of total leucocyte number per cubic mm of frog and human blood
- (f) Differential count of leucocytes in the human blood
- (g) Estimation of total erythrocyte count per cubic mm of blood
- (h) Cell permeability of RBC of human blood in saline solution of different concentrations

**2. Cytology:**

- (a) Study of different stages of mitosis with the help of onion root tip
- (b) Study of different stages of meiosis with the help of grasshopper testis
- (c) Laboratory preparation of following models using beads and wire
  1. Adenosine triphosphate (ATP)
  2. DNA and RNA bases
  3. Nucleosides
  4. Nucleotides

**3. Genetics:**

- (a) Morphological study of *Drosophila*
- (b) Preparation of chromosomal maps in *Drosophila* based on percent of crossing over
- (c) Genetics exercise (data to be provided)

**4. Endocrinology:**

- Endocrine glands of rat, insect (Location through models, Charts)
- Endocrine disorders (Photographs)

➤ **Following Practical's can also be conducted subject to the availability of infrastructure**

- Purity determination and quantitation of DNA
- Isolation of genomic DNA
- Electrophoresis of Proteins
- Electrophoresis of DNA - linear, circular and super coiled
- Southern blotting
- Western-blotting
- RFLP analysis
- Isolation of RNA
- Northern blotting.
- Nucleic acid hybridization
- Determination of  $T_m$  of nucleic acid
- Bacterial transformation
- Isolation of Plasmids
- Agglutination
- ELISA ( Demo online)
- Immuno fluorescence staining
- Exposure to RIA, Immuno-blotting
- Blood film preparation and identification of cells
- Haemocytometry
- Lymphoid organs and their microscopic organization
- Collection & storage of Serum.
- Double diffusion and Immuno-electrophoresis
- Immunodiagnosics (demonstration using commercial kits)
- Identification of blood group.
- Estimation of haemoglobin content in blood
- Isolation, purification and identification of immunoglobulin from blood
- Estimation of acid phosphatase from plant/animal sources
- Enzyme concentration by salt fractionation
- Determination of optimum pH, temperature,  $K_m$  value of an enzyme
- Bioinformatics–tools on line

**M.Sc. (Zoology) Semester III**  
**Paper – I Chordata**

**Section –A**

- **Classification up to orders**, habit and habitats and characters of Chordates
- **Characteristic features and Development** of: Urochordata , Cephalochordata
- **Affinities of the followings**: Hemichordata, Urochordata , Cephalochordata
- **Characters** and affinities of Cyclostomata
- **Salient features of different groups of Fishes**: Comparison between Chondrichthyes and Osteichthyes; Dipnoi
- **Origin of Amphibians**, General organization and affinities of Gymnophiona, Parental care in Amphibians

**Section – B**

- **Origin of Reptiles**, General organization, distribution and affinities of Rhynchocephalia and Crocodilia, Skull in Reptiles, Venom and anti-venom in Ophidians
- **Origin of Birds**, Flightless birds, Origin and mechanism of flight in birds, Modification of beaks, feet and palate in birds, Distribution, characters and affinities of Ratitae
- **Origin of Mammals**, General characters, distribution and affinities of Prototheria and Metatheria, Dentition in mammals, Stomach in ruminants, Adaptive radiations in mammals: Aquatic, Terrestrial, Aerial, Arboreal and Fossorial
- Aquatic and flying adaptations in mammals

## **Paper II – Animal Behaviour**

### **Section – A**

**Approaches to the study of animal behaviour:** Brief history, introduction, Significance of Study of Animal Behaviour, Animal Behaviour and Environment, Animal Behaviour and Animal Welfare, Animal Behaviour and Human Society, Tools and Techniques for the study of animals in wild: Animal Identification

#### **Behaviour Patterns:**

**(a). Fixed Action Pattern (FAP) or Instinctive Behaviour:** Characteristics, modes (Kineses, Taxes, Reflexes, Instincts), Releasers, Innate Releasing Mechanism (IRM)

**(b). Learned Behaviour or Acquired Behaviour:** Non-associative learning (Habituation, Sensitization), Associative learning (Classical conditioning, Trial and Error learning), Latent learning, Insight learning (Reasoning, Intelligence, Cognitive thinking), Phase-specific learning (Imprinting, Avian Song Learning, Language learning)

**(c). Memory:** Nature of Memory, Positive and Negative Memory (Reasoning, Remembering, Forgetting and Retention), Types of Memory (Short-term Memory (STM), Intermediate term Memory (ITM), and Long-term Memory)

**Individual Behaviour:** Conflicts (Situations, Types of conflicts, Behaviour display as an evidence of Conflict), Aggression (Forms and causes of aggression), Territoriality (Individual territories, Pair territories, Group territories, Use of scent, urine and faeces, and special glands such as anal and salivary glands in marking territories by Mammals)

**Feeding Strategies:** Non-selective and Selective feeding, Food begging, Courtship feeding, Predatory and Anti-predatory feeding mechanisms, Food sharing in insect societies, Parental feeding, Coprophagy

### **Section – B**

**Social Behaviour:** Costs and benefits of group living, Types of Social Acts, Social Organizations in Termites and Primates, Parental Care with emphasis on Insects, Fishes, Amphibians, Birds and Mammals

**Communication:** Visual and Auditory communication, Infrasound communication in Elephants and Whales, Tactile communication (Dance language of honey bees), Electric communication, Chemical communication (Pheromones: Types and their functions in Insects and Mammals), Echolocation in Bats, Postures and Gestures in Mammals

#### **Migratory Behaviour:**

**(a). Bird Migration:** Types of Migration, Causes of Migration, Advantages of Migration, Methods of Studying of Migration, Orientation and Navigation

**(b). Fish Migration:** Homing, Causes of Migration, Factors influencing Migration, Fish migration ways or Fish Ladders, Migration of Hilsa

**Biological Rhythm:** Circa annual Clocks, Circa tidal Clocks, Circa lunar or Circa syndic Clocks, Semi lunar Clocks, Circadian Clocks

## Paper III – Developmental Biology

### Section – A

**Fertilization:** Mechanism of fertilization, early and late changes in egg organisation caused by fertilization, molecular events during fertilization

**Cleavage and Blastulation:** Patterns of cleavage, determinate and indeterminate cleavage, influence of yolk on cleavage, metabolic changes during cleavage, morulation and blastulation in frog, chick and rabbit, types of blastulae

**Gastrulation:** Fate maps, morphogenetic movements in frog, chick and rabbit, significance of Gastrulation, exogastrulation

**Development** and functions of the foetal membranes in mammals

**Organogenesis:** Development of brain, eye and heart in chick

### Section – B

**Organizer Concept:** Embryonic induction, primary organiser and its morphological differentiation, origin of primary organiser, inductive interactions, nature of inductive signal (Possible mechanism of neural induction), competence

**Regeneration and Metaplasia:** Distribution of regenerative ability, polarity in regeneration, mechanism of regeneration of amphibian limb and lens, metaplasia, super-regeneration and heteromorphosis

**Metamorphosis:** Kinds of metamorphosis, metamorphosis in Amphibians, Physiological and biochemical changes during metamorphosis, hormonal control of metamorphosis.

**Teratogenesis:** Genetic and environmental Teratogenesis, phenocopies, developmental mechanisms of teratogenesis

**Ageing:** Theories of Ageing (Quantative Changes in Nucleic Acids, Changes in Information Content, Changes in Protection Regulatory Mechanisms, Free Radical Theory of Ageing), Ageing and Immunological Surveillance (Somatic Mutation Hypothesis, Function of Thymus, Immune Surveillance); Ageing of Connective Tissue; Mental Aspects of Ageing



## Paper – IV Biotechnology

### Section –A

- Origin, definition, scope and importance of biotechnology Biotechnology in India  
Basic introduction: Recombinant DNA Technology (Tools and techniques), Restriction and modification enzymes, Vectors: plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome Polymerase chain reactions, DNA fingerprinting, Southern , western and northern blotting, In-situ hybridization and Molecular markers
- **Gene therapy and Gene Delivery methods:** Background, types of gene therapy (ex vivo & in vivo), choosing targets for gene therapy, vectors in gene therapy, retroviruses, adenoviruses, adeno-associated viruses. Viral delivery (Retroviral vectors and Adenoviral vectors), Non-viral delivery. Vaccines – nucleic acid vaccines, biopharming and edible vaccines, immuno-enhancing technology
- **Transplantation biology:** terminology, technology behind it, organ donors, social & ethical issues, Xenotransplantation and tissue engineering
- Stem cell cultures, human ES cell culture, cryopreservation of Umbilical cord stem cells and their potential use

### Section – B

- **Genetic engineering in animals:** transgenic animals and their applications. Introduction to various transgenic animal models. Therapeutic products produced by genetic engineering- blood proteins, human hormones, immune modulators and vaccines, Embryo transfer technology and artificial insemination
- **Social issues of transgenics & IPR:** public opinions against the molecular technologies. Legal issues–legal actions taken by countries for use of the molecular technologies
- **Ethical issues:** Ethical issues against the molecular technologies. Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Intellectual Property Rights – Why IPR is necessary, TRIPS & IPR, IPR – national & international scenario, IPR protection of life forms
- **Bioremediation:** Petroleum prospecting and formation of oil spills, chemical degradation, heavy Metals. Introduction to Bioreactor: types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors

## Paper – V Bio-Instrumentation, Biostatistics and Computational Biology

### Section – A

- **Principles and techniques of Microscopy:** Magnification and resolution parameters of light, fluorescent phase contrast scanning, transmission electron microscopy, tunneling microscopy and Inverted microscope, Micrometry, Colony counting, Microtomy. Laboratory safety guidelines
- **Centrifugation:** Basic principles of sedimentation, types of centrifuges, ultracentrifugation, differential and rate zonal separations, Organellar separation and Flow cytometry
- **Principle & applications of pH meter:** Spectroscopy: UV- Vis, Mass Spectrometry (MS), X-ray Crystallography
- **Chromatographic techniques:** Paper Chromatography, Partition Chromatography, Column Chromatography, Thin Layer Chromatography, Gas Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Introduction to HPLC
- **Electrophoresis:** Capillary, Agarose, SDS & Native PAGE, pulse field, immuno-electrophoresis, paper electrophoresis
- **PCR & Thermal cyclers, Autoradiography, ELISA**

### Section – B

- **Introduction to computers:** Computer fundamentals (Hardware & Software), Input, Output devices and Storage devices, Web Browsers, Search Engines, Flow charts, Methods and types of networks, Intra and Internet, Introduction to MS-office
- **Introduction to Bioinformatics:** Scope and application of Bioinformatics, NCBI Data model, DNA and Protein Sequence database, Motif analysis, structural database, Structural Viewers (RasMol, RasTop, Cn3D, CSHF Chimera, Swiss PDB Viewer, PyMOL), Sequence submission to database, Literature database (PubMed, Biomed Central, Medline), Internet and biologist. Online study *E. coli*, *D. melanogaster*, Human genome, Mice genome. DNA Chips and their replications
- **Introduction to Biostatistics:** Terminology and symbols, applications of statistics in biological research, collection and representation of data, measures of central tendency (Mean, Median, Mode), Coefficient of variation, Standard Deviation, Analysis of variation (ANOVA), measures of dispersion, distribution patterns (Binomial, Poisson & normal), tests of significance ('t' test, 'F' test & chi-square test), probability, correlation and regression analysis, Introduction to statistical software and handling

**M.Sc. (Zoology)**  
**III<sup>rd</sup> Semester Practical**

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session.

The practical work shall comprise of:

1. Microtomy of vertebrate tissues
2. Study of the skeleton of Frog, Varanus, Snake (vertebrae and skull of poisonous and non-poisonous snake), Gallus (various types of Palates) and Rabbit
3. Study of permanent slides of Protochordata and Chordates
4. Study of the museum specimens of Protochordata and of the different classes of vertebrates
5. **Exercices on Developmental Biology:**
  - Study of eggs from collected / preserved material
  - Study of development of frog, chick through models/charts
  - Study of chick embryos from 16-18 hrs, 24-28 hrs 33-36 hrs, 42-72 hrs of development (Whole mount models, charts)
  - Study of development of chick by window method

6. **Instrumentation:**

Comments including principle, functioning and utility of some common instruments like Microscopes, Microtome, Colorimeter, Spectrophotometer, Centrifuge, Electrophoresis etc.

7. Calculation of mean, median, mode, standard deviation, standard error from the data provided

➤ **Following Practical's can also be conducted subject to the availability of infrastructure**

- Plasmid isolation by alkaline lysis and boiling method
- Transformation of plasmid using competent bacterial cells
- Restriction mapping
- Cloning

- PCR.
- DNA sequencing
- Isolation of Lambda phage DNA
- Cloning in plasmid
- Preparation of single stranded DNA template
- DNA sequencing, Preparation of tissue culture medium and membrane filtration
- Preparation of single cell suspension from spleen and thymus
- Cell counting and cell viability
- Chick fibroblast culture
- Trypsinization of monolayer and sub-culturing
- Transfection of cultured monolayer
- Cryopreservation and thawing
- Measurement of doubling time.
- Role of serum in cell culture
- Preparation of metaphase chromosomes from cultured cells
- Isolation of DNA and demonstration of apoptosis of DNA laddering
- Cell fusion with PEG
- Permanent slide preparation setting up and maintenance of fish hepatocytes /murine macrophages
- Analysis of water for potability and determination of MPN
- Detection of coliforms for determination of the purity of potable water
- Determination of total dissolved solids of water
- Determination of dissolved oxygen concentration of water sample
- Determination of biological oxygen demand (BOD) of a sewage sample
- Determination of chemical oxygen demand (COD) of sewage sample
- Determine the efficiency of removal of air pollutants using fibrous air filter
- Isolation of xenobiotic degrading bacteria by selective enrichment technique
- Test for the degradation of aromatic hydrocarbons by bacteria
- Survey of degradative plasmids in microbes growing in polluted environment
- Effect of sulphur dioxide on crop plants
- Estimation of heavy metals in water/soil by Atomic absorption spectrophotometer
- Estimation of nitrate in drinking water
- Study on biogenic methane production in different habitats
- Isolation of industrially important microorganisms for microbial processes
- Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism for design of a sterilizer
- Comparative studies of Ethanol production using different substrates
- Microbial production of Citric acid using *Aspergillus niger*
- Microbial production of antibiotics (Penicillin)
- Production and estimation of Alkaline Protease
- Use of alginate for cell immobilization

**M.Sc. (Zoology) Semester IV**  
**Specialization (Fish and fisheries)**  
**Paper – I (a) General Ichthyology**

**Section – A**

- **Classification of fishes**, Systematic position, habit and habitat, morphology, distribution, significance and affinities of Holocephali and Dipnoi
- **Fins**, their origin and evolution
- **Locomotion in fishes**
- **Histomorphology** and elementary physiology of digestive system (with particular reference to food and feeding habits of freshwater fishes) and excretory system (with particular reference to acid base balance and osmoregulation)
- **Electric** organs in fishes
- **Accessory** respiratory organs in fishes

**Section – B**

- **Brief knowledge of sense organs**: organs of smell, eyes, hearing, ampulla of Lorenzeni, Bio- luminescence, sound production and lateral line system.
- **Brief knowledge** of sexual dimorphism and courtship
- **Reproduction in a major carps**: structure of gonad, spawning, early development and metamorphosis
- **Parental care in fishes**
- **Microscopic structure and hormonal functions of the following endocrine glands**: Pituitary, Thyroid, Pancreas, Adrenal, Corpuscles of Stannins, Ultimobranchial glands, caudal neurosecretory system and Sex hormones
- **Migratory instincts**
- **Hill stream adaptations**
- **Venomous** and non-venomous fishes
- **Fish pheromones**, Coloration in fishes

**Specialization (Fish and Fisheries)**  
**Paper – II (a) Applied Ichthyology**

**Section – A**

- General survey of the marine, estuarine and inland capture fisheries of India with particular reference to fishery resources of Uttaranchal, Methods of fishing: Fishing gears and crafts, Cold water fishery, Sewage-fed fishery, Shell-fish fishery
- Nutrition and growth including age and growth relationship, chemical composition of fish flesh, length-weight relationship, Natural food and artificial feed and their role in fish culture, Plankton and benthos in relation to fish production
- Fish preservation, transport and marketing, Ecology and productivity of fish ponds, Pollution in relation to fisheries

**Section – B**

- **Carp culture:** Mono culture, Poly culture and Composite fish culture, Live fish culture Management practices: weed, insect, and carnivorous fishes, Maturation and fecundity, spawning and seed collection, hatching techniques and hatcheries, rearing, stocking, transport and mortality of fish
- **Integrated Aquaculture:** Fish-cum poultry, Fish-cum duckery, Fish-cum piggery, Paddy-cum fish culture and Dairy-cum fish culture
- Induced spawning and hybridization, Factors responsive for induced breeding, hypophysation, Use of different synthetic and natural hormones
- **Larvivorous fishes** and public health
- **Fish diseases** and their management
- **Exotic fishes** and their merits and demerits
- **Cryopreservation** of gametes and embryos
- **Ornamental fish culture**

## **IV<sup>th</sup> – Semester Practical**

### **Specialization (Fish and Fisheries)**

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session.

#### **The practical work shall comprise:**

1. Detailed study of the skeleton of a Cyprinoid and a Siluroid fish
2. Permanent preparation of scales, sensory, Ampullae etc.
3. Taxonomic studies of fresh water fishes
4. Ecological study- Estimation of dissolved oxygen, carbon dioxide and pH of pond water
5. Determination of age with the help of scales
6. Calculation of Gonado-Somatic Index and Gastro-Somatic Index
7. Determination of fish fecundity
8. Extraction of Pituitary gland
9. Sham injection of Pituitary gland extract
10. Analysis of gut content
11. Study of length-weight relationship

#### **Exercises on Fish habitat Ecology**

1. Determination of CO<sub>2</sub>
2. Determination of DO
3. Determination of PH
4. Determination of turbidity
5. Measurement of primary productivity
6. Qualitative and quantitative analysis of phytoplankton
7. Qualitative and quantitative analysis of Zooplankton
8. Qualitative and quantitative analysis of benthos
9. Determination of total alkalinity
10. Determination of hardness

#### **Exercises on Fisheries Biology**

1. Models on dissection of cranial nerves of fish and accessory respiratory organs
2. Determination of age with the help of scales
3. Calculation of Ganado-somatic index
4. Calculation of Gastro-somatic index
5. Determination of Fish fecundity

6. Extraction of pituitary gland
7. Sham injection of pituitary gland extract
8. Analysis of gut contents
9. Study of length weight relationship

**Fish Physiology and Biochemistry:**

1. Estimation of Protein
2. Estimation of glucose
3. Estimation of Lipids
4. Estimation of haemoglobin in fish blood
5. Counting of erythrocytes/ RBC in fish blood



**M.Sc. (Zoology) Semester IV**  
**Specialization (Entomology)**  
**Paper I (b): Systematics and Applied Entomology**

**Section – A**

**Ancestry and** evolution of insects

**Classification** of insects

**Principles of** construction and use of dichotomous keys in insect identification

**Methods of** collection, preservation and culture of insects

**Parental care** in insects

**Brief knowledge of habit, habitats and general characters of** the following orders with special reference to the families mentioned: **Thysanura** (Machilidae, Lepismatidae), **Collembola**, **Odonata**, **Orthoptera** (Acrididae, Tettigonidae, Gryllidae), Phase theory in locusts, **Phthioptera** (Anoplura, Mallophaga), **Isoptera**, **Thysanoptera**, **Heteroptera** (Pentatomidae, Belostomatidae), **Homoptera** (Aphidae, Coccidae), **Coleoptera** (Coccinellidae, Curculionidae, Scarabaeidae), **Lepidoptera** (Noctuidae, Nymphalidae, Papilionidae), **Hymenoptera** (Ichneumonidae, Chalcididae, Formicidae); **Diptera** (Culicidae, Muscidae, Syrphidae)

**Section – B**

**Principles and Practices of Pest Control:**

- (a) **Pests defined:** Categories of crop pests (key pests, occasional pests, potential pests and migratory pests)
- (b) **Pest control procedures:** Natural control, Applied control (Cultural, Biological and Insecticidal)
- (c) **Modes** of action of insecticides, factors affecting toxicity of insecticides
- (d) **Non-insecticidal** methods : Antifeedents, Attractants and Repellents, Feeding deterrents, Chemosterilants, Pheromones and Insect Growth Regulators (IGR's)
- (e) **Integrated** Pest Management (IPM)
- (f) **Insecticide Application Equipments:** Sprayers, Dusters, Granule Applicators

**Distribution, habit and habitats, life-cycle, nature of damage and control of pests of:**

**Stored grains** (*Sitophilus oryzae*, *Callosobruchus chinensis*); **Sugarcane** (*Pyrilla perpusilla*, *Chio infuscatellus*); **Paddy** (*Leptocorisa acuta*, *Hieroglyphus banian/nigrorepletus*), **Cotton** (*Dysdercus koengii*, *Pectinophora gossypiella*); **Cereals** (*Heliocoverpa armigera*, *Agrotis ypsilon*) **Vegetables** (*Raphidopalpa (=Aulacophora) foveicollis*, *Pieris brassicae*); **Fruits** (*Bactrocera (=Dacus) cucurbitae*, *Papilio demoleus*); **Forests (Defoliator:** Tasar silkworm,

*Antheraea paphia*; **Sap-sucker** of Khamer or Gamhar, *Tingis beesoni*; **Teak borer**, *Aeolesthes holosericea*); and **Polyphagous Pests** (Locusts, Termites)

**Lac Industry:** Strains of lac insects, lac cultivation, composition and uses of lac

**Apiculture:** Kinds of Honey bees, organization of Honey bees, the language of Honey bees, Bee keeping methods, economic importance and diseases of Honey bees

**Sericulture:** Mulberry and Non-mulberry Sericulture, composition and uses of silk

**Life-cycle and control of insects of Medical Importance of Man and Animals:** House flies, Mosquitoes, *Phelbotomus* (Sandfly) , *Tabanus* (Horse fly)

## Specialization (Entomology)

### Paper II (b) – Biology of Insects: Morphology, Physiology & Development

#### Section – A

**Integument:** Structure, functions and modifications of insect cuticle, moulting and sclerotization

**Structure** of an insect head, thorax and abdomen; Appendages of head (mouthparts and antennae) and thorax (legs and wings)

**Structure** of a wing of an insect, types of wings, hypothetical wing venation, wing-coupling mechanisms, and flight mechanism

**Structure** and modifications of male and female genitalia in insects

**Structure and** modifications of alimentary canal; food and feeding mechanism of a generalised insect with special reference to physiology of digestion in different insects

**Structure** and functions of blood and mode of circulation in insects

**Principal organs** of excretion of insects found in different habitats, physiology of excretion with special reference to osmoregulation in insects

**Structure and functioning** of various types of respiratory organs, modes of respiration, physiology of respiration in terrestrial, aquatic and endoparasitic insects

#### Section – B

**Generalized** plan of nervous system in insects and its modifications

**Neuroendocrine** system in insects and the role of neurosecretion in various metabolic activities, metamorphosis and development of insects

**Structure and** functions of different types of visual and sound producing organs in insects

**Structure,** function and physiology of mechanoreceptors and chemo receptors in insects

**Bioluminescence:** Light producing organs, mechanism and significance of light production in insects

**Structure of pheromone** producing glands, different types of pheromones and their chemical nature

**Structure and modification** of male and female reproductive systems in insects

**Development:** Structure of egg, maturation, cleavage, blastokinesis, formation of germ layers and segmentation; different types of larvae and pupae

**Polyembryony** and parthenogenesis in insects

## **IV<sup>th</sup> – Semester Practical**

### **Specialization (Entomology)**

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise of following exercises:

1. Study of models on dissection of nervous system of insects
2. Permanent preparation of sting apparatus of honey bee/wasp, tympanum of locust, salivary glands of Cockroach, antennae, mouth parts, legs and wings of different insects.
3. Counting of haemocytes in insects
4. Modifications of insect heads on the basis of their orientation
5. Identification of insects up to family of the orders prescribed in theory
6. Study of the different types of adaptations found in insects
7. Determination of pH of the gut contents
8. Microtomy of insect tissues
9. Pests of fruits, vegetables & stored grains
10. Study of the structure of bee-hive
11. Bioassay studies on insects using some contact poisons
12. Use of dichotomous key in the identification of insects
13. Study of the life-cycles of some important insect pests
14. Determination of Shannon-Weiner diversity index from given data
15. Estimation of secondary productivity from the given data using Wiegert's (1965) expressions
16. Exercises on insect behaviour

**M.Sc. (Zoology) Semester IV**  
**Specialization (Animal Biotechnology)**  
**Paper I (c) (Animal Cell Culture)**

**Section – A**

- **Animal Cell Culture:** Equipment and materials for animal cell culture technology, Design and layout of culture room, Sterilization and aseptic techniques. Culture medium: natural media, synthetic media, sera. Introduction to balanced salt solutions and simple growth medium, Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, role of carbon dioxide, serum and supplements in animal cell culture, Characteristics of cells in culture: Contact inhibition, anchorage dependence, cell-cell communication
- **Maintenance of animal cell culture:** Mechanical and enzymatic disaggregation of tissue and setting up of primary cultures, Candling of eggs, preparation of chick fibroblast, culture of lymphocytes for chromosomal studies, Roller and Suspension culture techniques, Large-scale production of cells using bioreactors, micro-carriers and perfusion techniques. Fermentation technology for the growth of animal cells and their products (Bioreactors, Hollow fiber reactors, Air-lift fermentors, chemostats and microcarriers), Established cell line cultures: Definition of cell lines, maintenance and management; cell adaptation, Stem cell cultures, embryonic stem cells and their applications, Somatic cell genetics, Organ and histotypic cultures

**Section – B**

- **Biology and Characterization of cultured cells:** Measurement of viability and cytotoxicity, Biological characterization of the cultured cells, karyotyping, cryopreservation and revival, Detection of contaminants in cell cultures, Cell cloning, cell synchronization and cell manipulation, Various methods of separation of cell types, advantages and limitations, flow cytometry, Production and characterization of monoclonal antibodies and their application
- **Commercial applications of animal cell culture:** cell culture based vaccines, Tissue culture as a screening system, cytotoxicity, in vitro testing of drugs and diagnostic tests, Mass production of biologically important compounds (e.g. Vaccines and Pharmaceutical proteins), Production of recombinant hemoglobin, blood substitutes, artificial blood Harvesting of products, purification, and assays, Three dimensional cultures and tissue engineering (artificial skin and artificial cartilage)

## **Specialization (Animal Biotechnology)**

### **Paper II (c) (Transgenics, Cloning and IPR)**

#### **Section – A**

- **Gene transfer technology in animals:** Viral and non-viral methods, sperm mediated gene transfer, transfection of animal cell lines and their immortalization, gene knock out animal models, current status of production of transgenic animals, Animal cloning: Techniques, relevance, case studies and ethical issues
- **Genetic engineering of mammalian cells:** In vitro fertilization (IVF) in humans, embryo transfer (ET) technology in humans, superovulation, Micromanipulation, IVF and embryo culture in farm animals (e.g. cow), embryo transfer in cattle, Gene transfer or transfection (using eggs and cultured stem cells): targeted gene transfer; transgenic animals (mice, sheep, pigs, rabbits, goats, cows, fish)

#### **Section – B**

- **Introduction to Biosafety regulations:** Primary Containment for Biohazards and Biosafety Levels, Biosafety guidelines – Government of India, Definition of Genetically modified organisms (GMOs) & living modified organisms (LMOs), Roles of Institutional animal ethical committee, Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC) etc., Prevention of cruelty on animals act Govt. of India, Concept of Bioethics, Public concerns on Human genome research and transgenics-Genetic testing and screening, Ethics in clinical trials and Good Clinical Practices(GCP), Ethical, legal, and social implications(ELSI) & Human genome project, Ethics in human cloning, patenting human genes
- **Intellectual property rights and its types:** Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of new GMOs, Basics of patents (Types, patent application and Specifications), concept of Prior Art and patent filling procedures, Process patent vs product patent. Introduction to General Agreement on Tariffs and Trade (GATT), World Trade Organization (WTO), World Intellectual Property Organization (WIPO) and Trade Related Intellectual Property Rights (TRIPS)

## **IV<sup>th</sup> – Semester Practical**

### **Specialization Animal Biotechnology**

- Preparation of single cell suspension from spleen and thymus
- Preparation serum
- Egg Preparation of tissue culture medium and membrane filtration
- candling
- Cell counting and cell viability
- Chick fibroblast culture
- Trypsinization of monolayer and sub-culturing
- Transfection of cultured monolayer
- Cryopreservation and thawing
- Measurement of doubling time
- Role of serum in cell culture
- Preparation of metaphase chromosomes from cultured cells
- Isolation of DNA and demonstration of apoptosis of DNA laddering
- Cell fusion with PEG
- Permanent slide preparation setting up and maintenance of fish hepatocytes /murine macrophages

**Recommended books:**

1. Introduction to Plant Biotechnology, H.S Chawla, Raju Primlani for Oxford & IBH Publishing Co.Pvt.Ltd. Delhi.2002.
2. Animal Biotechnology, R Sasidhara, MJP Publishers. Chennai.2006.
3. Animal Biotechnology, A.K Srivastava R.K Singh,M.P Yadav, Mohan Primlani for Oxford & IBH Publishing Co.Pvt.Ltd. New Delhi.2005.
4. Genetic Engineering, Sandhya Mitra, Rajiv Beri for Macmillan India Limited. New Delhi.1996.
5. Biotechnology, B.D Singh, Kalyani Publishers.Ludhiana.1998.
6. Biotechnology, U.Satyanarayana, Books and Allied (P) Ltd.Kolkata.2005.
7. Culture of Animal Cells: A Manual of Basic Technique, Fifth Edition, R. Ian Freshney, John Wiley & Sons, Inc.2005.
8. Animal Biotechnology: Science Based Concerns, John G. Vandenberg, The National Academies Press Washington, D.C. 2002.
9. Animal Transgenesis and Cloning, Louis-Marie Houdebine, John Wiley & Sons Ltd.England.2003.
10. Aquaculture and Fisheries Biotechnology Genetic Approaches, R.A. Dunham, CABI Publishing. Cambridge, USA. 2001.
11. Stem cell research: medical applications and ethical controversy, Joseph Panno, Library of Congress Cataloging-in-Publication Data.2005.
12. Animal Cell Culture: A Practical Approach (Practical Approach Series), John R.W Masters, United states of Oxford University Press Inc. New York, 1989.
13. Molecular Cloning A LABORATORY MANUAL, Fourth Edition, Michael R. Green & Joseph Sambrook. Cold Spring Harbor Laboratory Press. New York, 2012.



**M.Sc. (Zoology) Semester IV**  
**Specialization (Immunology)**  
**Paper I (d) Fundamentals of Immunology**

**Section – A**

**Introduction and Historical Background: Cells and Organs of Immune system**

Definition, Overview of immune system- Anatomical, Physiological and Inflammatory barriers. Major contribution of following scientists- Edward Jenner, Jacob Henle, Louis Pasteur, Joseph Lister, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Emil von Behring, Jules Bordet, Karl Landsteiner, Jules Freund, Peter Gorer and George Snell, Tiselius and Kabat, Gerald Edelman and Rodeny Porter, Cesar Milstein and Georges Kohler, Peter Doherty and Rolf Zinkernagel  
Hematopoiesis – formation of B-lymphocytes and T-lymphocytes and its regulation. Cells of the immune system- NK Cells, B-lymphocytes, T-lymphocytes, Granulocytic cells, Dendritic cells  
Primary lymphoid organs and their functional role- Bone marrow, Thymus. Secondary lymphoid organs and its functional role- Lymph nodes, Spleen, Mucosal-Associated Lymphoid Tissue [MALT], Intraepithelial Lymphocytes [IEL], Cutaneous-Associated Lymphoid Tissue [CALT]

**Antigen and Immunogen, Structure and Function of Immunoglobulins, Structure and function of MHC:**

Antigen- definition and its properties. Immunogen-definition and its properties. Antigenicity vs. Immunogenicity and factors affecting it. Haptens and Adjuvants. Basic structure of immunoglobulin. Classes of immunoglobulin and its biological activities. Major Histocompatibility Complex [MHC] - Structure, types and function. Regulation of MHC expression. Production of Monoclonal antibodies, its mechanism [de novo and salvage pathway] and application in research and health.

**Section – B**

**Primary and Secondary line of Defence [Innate and acquired immunity], Antigen-Antibody interactions:**

Innate immunity- Phagocytic barriers. Antigen presenting cells. Antigen processing and presentation. Acquired immunity- B-cell mediated immunity, T-cell mediated immunity its mechanism and regulation. Immune memory of B-lymphocytes.  
Interaction of Antigen-Antibody- antibody affinity, antibody avidity, cross reactivity, precipitation reactions, Agglutination reactions.

**Immune effector mechanism, Allergy and Hypersensitivity:**

Cytokines- Properties and its receptors. Cytokine secretion by Th1, Th2 and Th17 subsets and its function. The Complement system: its components, functions, activation and regulation. Complement deficiencies.  
Allergy, Hypersensitivity: Gell and Coombs classification, IgE mediated [type I] Antibody-mediated cytotoxicity [type II], immune complex-mediated [type III] and T<sub>DTH</sub>-Mediated [type IV] hypersensitivity.

**Recommended books:**

1. Kuby's immunology- Goldsmith et al, 6<sup>th</sup> Ed, WH Freeman, New York, USA.
2. Basic immunology: functions and disorders of immune system- Abbas, Litchman. Saunders Publications, Philadelphia, USA
3. Janeway's Immunology- Kenneth Murphy, 8<sup>th</sup> Ed, Garland Science, Pennsylvania, USA.
4. Roitt's Immunology- Delves et al, 12<sup>th</sup> Ed, Willey-Blackwell Science, Oxford, UK.
5. History of Immunology, 2<sup>nd</sup> Ed- Silverstein [2009], Academic Press, New York, USA.
6. Exploring immunology: Concepts and Evidence- Macpherson and Austyn, Willey-Blackwell Science.

**Recommended Journals:**

1. Annual Reviews of Immunology
2. Nature Reviews Immunology
3. Immunology Reviews
4. Seminars in Immunology
5. Annual Reviews of Physiology

**M.Sc.(Zoology) Semester IV  
Specialization (Immunology)**

**Paper II (d) Applied Immunology**

**Section – A**

**Immune response to infectious diseases:**

Mechanism of immune response during: viral infections [Influenza, HIV], bacterial infections [*Corynebacteria*, *Mycobacterium*] protozoan infection [*Plasmodium*, *Trypanosoma* and *Leishmania*], Helminthes infections [*Ascaris*, *Schistosoma*].

**Disease of immune system and vaccines:**

Mechanism of autoimmune diseases- Systemic Lupus Erythematous [SLE], Myasthia gravis, Rheumatoid arthritis, celiac disease. Cancer of blood cells- Lymphoma and Leukemia [Hodgkin and Non-Hodgkin]. Vaccines- historical background, routine vaccines, DNA vaccines, snake-antidotes. Production of monoclonal antibodies and its mechanism.

**Section – B**

**Immunotechnology:**

Separation of immune cells by flowcytometry [FACS]: Its principle and application. Principle and application of immunoprecipitation. Functioning and application of microscopes: Immunofluorescence and confocal. Principle and application of *in-situ* hybridization technology-FISH [Fluorescence *In-Situ* Hybridization] and GISH [Genome *In-Situ* Hybridization]. Principle, methodology and application of following techniques- ELISA [Enzyme Linked Immunosorbent Assay], RIA [Radio Immuno Assay], Western blotting. Allergy evaluation: Principle and methodology of skin prick test for allergy.

**Transplantation immunology:**

Transplantation- History, graft vs. host rejection studies for specific transplantation i.e skin graft, kidney, liver and heart with reference to hyperacute, acute and chronic rejection and its mechanism. Immunosuppression- definition, drugs used for Immunosuppression and its mechanism of action. Xenotransplantation- definition and its application. Graft vs. host reaction and diseases- definition, mechanism, treatment and prevention. HLA phenotyping, lymphoproliferation assay, its working principle and applications. Blood groups- MN, ABO blood group and blood transfusion.

**Recommended books:**

1. Kuby's immunology- Goldsmith et al, 6<sup>th</sup> Ed, WH Freeman, New York, USA.
2. Practical Immunology, 4<sup>th</sup> Ed. Hay and Westwood [2002]. Blackwell Science Ltd, Oxford, UK.
3. Advanced method in cellular immunology. Fernandez-Borton and Velvaticka [2000]. CRC press, Washington, USA.
4. Clinical immunology and Serology: a practical perspective, 3<sup>rd</sup> Ed. Stevans [2010], FA Davis co. Philadelphia, USA.

**Recommended research database:**

1. Pubmed [[www.ncbi.nlm.nih.gov/pubmed](http://www.ncbi.nlm.nih.gov/pubmed)]
2. Science direct [[www.sciencedirect.com](http://www.sciencedirect.com)]
3. Nature publishing group [[www.nature.com](http://www.nature.com)]
4. Cochrane library [[www.cochranelibrary.org](http://www.cochranelibrary.org)]
5. High wire [[www.stanfordhighwire.org](http://www.stanfordhighwire.org)]

**IV<sup>th</sup> – Semester Practical**  
**Specialization Immunology**

The practical shall comprise:-

1. Cell viability test using chicken or got spleenocyte. [Methylene blue dye exclusion test]
2. Determination of ABO blood group.
3. Ouchterloney's didiffusion immunoassay.
4. Study of primary and secondary lymphoid organs through microphotograph or models or chart.

OR

Dissection and display of secondary lymphoid organs in laboratory mice/rats [after due approval from college animal ethics committee].

5. Use of flowcytometry to separate specific immune cells [separation of T-cells, B-cells, Stem cells etc. [Dry lab exercise in case lab facility is not available].
6. Immunoprecipitation dry lab exercise.
7. Performance of ELISA test [Dry lab exercise in case lab facility is not available].
8. Immunohistochemistry [Dry lab exercise in case lab facility is not available].
9. Western blotting [Dry lab exercise in case lab facility is not available].
10. Dissertation work.