Kumaun University
Department of Zoology
M.Sc. Zoology

Syllabus:

There shall be 16 Core courses, 15 Elective courses and 2 open elective course including Practical courses, total credits 80 and the entire course will carry 2000 Marks.

CC - Core Courses

EC - Elective Courses

OEC - Open Elective Courses

Course structure of M.Sc. Zoology

Total Credits: 80 **Total marks: 2000**

S.N	Course Code	Name of Course	Type of course	Credit distribution			Total Credits	Marks (scaled)
				L	T	P		
FIRST SEMESTER: 20 CREDITS								
1	**ZOO/I/CC/01**	**Microbiology**	CC	12	4	-	4	100
2	**ZOO/I/CC/02**	**Non-Chordata**	CC	12	4	-	4	100
3	**ZOO/I/CC/03**	**Taxonomy and Evolutionary Biology**	CC	12	4	-	4	100
4	**ZOO/I/CC/04**	**Molecular Biology**	CC	12	4	-	4	100
5	**ZOO/I/CC/05**	**Lab based on CC/01 to CC/04**	CC	-	-	4	4	100
SECOND SEMESTER: 20 CREDITS								
1	**ZOO /II/CC/01**	**Cell Biology and Genetics**	CC	12	4	-	4	100
2	**ZOO /II/CC/02**	**Mammalian Endocrinology**	CC	12	4	-	4	100
3	**ZOO /II/CC/03**	**Biochemistry**	CC	12	4	-	4	100
4	**ZOO /II/CC/04**	**Animal Physiology**	CC	12	4	-	4	100
5	**ZOO /II/CC/05**	**Lab based on CC/01 to CC/04**	CC	-	-	4	4	100
THIRD SEMESTER: 20 CREDITS								
1	**ZOO /III/CC/01**	**Chordata**	CC	3	1	4	4	100
2	**ZOO /III/CC/02**	**Lab based on CC/01**	CC	-	-	4	4	100
3	**ZOO /III/EC/01**	**Biotechnology**	EC	3	1	4	4	100
4	**ZOO /III/EC/02**	**Animal Behavior**	EC	3	1	4		100
5	**ZOO/III/EC/03**	**Bioinstrumentation, Biostatistics and Computational Biology**	EC	3	1	4	4	100
6	**ZOO /III/OEC/01**	**Developmental Biology**	OEC	3	1	-	4	100
FOURTH SEMESTER: 20 CREDITS, Elective Courses								
1	**ZOO/IV/CC/01I**	**General Ichthyology**	CC	3	1	4	4	100
2	**ZOO/IV/EC/I01**	**Applied Ichthyology**	EC	3	1	4	4	100
3	**ZOO/IV/EC/I02**	**Basic Limnology**	EC	3	1	4	4	100
4	**ZOO/IV/EC/I03**	**Animal Ecology**	EC	3	1	4	4	100
OR								
1	**ZOO/IV/CC/01E**	**Systematic and Applied Entomology**	CC	3	1	4	4	100
2	**ZOO/IV/EC/E01**	**Biology of Insects (Morphology, Physiology and Development)**	EC	3	1	4	4	100
3	**ZOO //IV/EC/E02**	**Economic Zoology and Vermicology**	EC	3	1	4	4	100
4	**ZOO //IV/EC/E03**	**Wildlife Conservation**	EC	3	1	4	4	100
OR								
1	**ZOO /IV/CC/01B**	**Animal Biotechnology (Animal cell Culture)**	CC	3	1	4	4	100

2	**ZOO /IV/EC/B01**	**Animal Biotechnology (Transgenics, cloning and IPR)**	EC	3	1	4	4	100
3	**ZOO /IV/EC/B02**	**Medical Laboratory Techniques**	EC	3	1	4	4	100
4	**ZOO /IV/EC/B03**	**Wildlife Conservation**	EC	3	1	4	4	100
OR								
1	**ZOO /IV/CC/011M**	**(Immunology) Fundamentals of Immunology**	CC	3	1	4	4	100
2	**ZOO /IV/EC/IM01**	**(Immunology) Applied Immunology**	EC	3	1	4	4	100
3	**ZOO /IV/EC/IM02**	**Animal Ecology**	EC	3	1	4	4	100
4	**ZOO /IV/EC/IM03**	**Medical Laboratory Techniques**	EC	3	1	4	4	100
5	**ZOO/IV/OEC/01**	**Minor Project (In-house) on Final Semester special papers (I, II and III)**	OEC				4	100
6	**ZOO /IV/CC/02**	**Lab based on Final Semester special papers (I, II and III)**	CC	3	1	4	4	100

FIRST SEMESTER: 20 CREDITS

ZOO/I/CC/01	Microbiology	Credits: 4	Max. Marks: 100

Unit-I

- **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 and Slime moulds.

- **Microorganisms in their natural habitat:** Atmosphere, Hydrosphere, Lithosphere & Extreme habitats. Microbial interaction (Symbiotic and asymbiotic).

Unit-II

- **Microbial morphology and physiology:** Bacteria (typical structure and classification, chemical composition, nutrition, locomotion, reproduction and cultivation) 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 and growth curve types, Measurement of growth and growth yields, Synchronous growth, Growth as affected by environmental factors like temperature, acidity, pH, water availability and oxygen.

Unit-III

- **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. Types of vaccines (Live-Attenuated vaccines, inactivated vaccines, Recombinant vaccines, Polysaccharide vaccines and conjugate vaccines).Global pandemics due to various viruses including Corona virus
- **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 (Aeromicrobiology):** Distribution of microorganisms in air, Aeroallergens, collection and enumeration of aerial microorganisms.

Unit-IV

- **Microbiology of food:** Microbial contamination and spoilage of industrial and domestic food, sources of food poisoning, preservation of foods. Fermentation and fermented 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 borne, 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.

ZOO/I/CC/02	Non- Chordata	Credits: 4	Max. Marks: 100

Unit-I

- General classification, characters, habits and habitats of non-chordates
- Protozoa: Nutrition, Locomotion (Amoeboid, Flageller and Ciliary movements) and reproduction in protozoa; Life-cycle of *Trypanosoma, Entameoba histolytica, Giardia* and *Leishmania*.
- Porifera: Canal system and phylogeny. Reproduction in Porifera

Unit-II

- Coelenterata: Polymorphism in Coelenterata. Structure and affinities of Ctenophora, Coral and coral reefs.
- Helminthes: Life cycle of *Taenia solium, Fasciola hepatica, Wuchereria* and *Schistosoma*. Parasitic adaptations in helminthes.
- Minor phyla: Rotifera and Brachiopoda: Organization and affinities.

Unit-III

- Annelida: Segmental organs, Adaptive radiations in Polychaeta.
- Arthropoda: Larval forms in. Crustacea. Mouth parts in insects. Social life in honeybees and termites. Onychophora: Organization and affinities.

Unit-IV

- Mollusca: Torsion in Mollusca. Pearl formation and its commercial importance, respiratory and reproduction in Mollusca.
- Echinodermata: Water vascular system and larval forms
- Mechanism of Osmoregulation in invertebrates.

ZOO/I/CC/03	Taxonomy and Evolutionary Biology	Credits: 4	Max. Marks: 100

Unit-I

- Introduction to Systematics and Taxonomy: Significance and brief History of Taxonomy
- Modern approaches in Taxonomy
- Concepts of Zoological classification: functions, systems of classification (Two Kingdom and Five Kingdom system of classification), Linean hierarchy, Taxonomic Aids (Museums, National Parks, and Keys)

Unit-II

- 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.
- Modern Synthetic Theory: Genetic variability in populations (Ecads and Ecotypes), Significance of Genetic Variability, Natural Selection. Genetic Drifts, Hardy-Weinberg Genetic Equilibrium, Isolation, Origin of New Species.

Unit-III

- Variations: Nature of Variations, Kinds of Variations (Meristic and Substantive, Continuous and Discontinuous, Determinate and Indeterminate, Somatic and Germinal, Polymorphic, Cryptic and Geographical Variations).
- The Origin of Species: Concepts of Species, categories of species (Demes, Metapopulation, Geographical Races, Ecological Races, Climes), Types of Species (Sibling species, Monotypic and Polytypic species)

Unit-IV

- Speciation: Phyletic Speciation, Quantum Speciation, Gradual Speciation (Allopatric, Peripatric, Sympatric, Parapatric)
- Basic Patterns of Evolution: Microevolution, Macroevolution and Mega evolution, Mechanisms of evolution, Essential features of Macroevolution and Mega evolution. Evolution of Man, Geological time scale period.
- Mimicry and Protective Coloration: Kinds of Mimicry (Protective Mimicry, Aggressive, Batesian and Mullerian), Significance of Mimicry; Coloration (Color Production, Biological Significance of Coloration)

ZOO/I/CC/04	Molecular Biology	Credits: 4	Max. Marks: 100

Unit I

- Introduction to Molecular Biology: Structure and organization of genome. Human genome project, Law of DNA constancy, C_ot curve (cot curve), c-value paradox, DNA renaturation kinetics, Determination of Tm value.

- Chemistry of gene: Structure of nucleic acids (A, B, C and Z-DNAs, RL-model of Sasisekharan; supercoiling; genetic and non-genetic RNAs), Watson and Crick Model of DNA. DNA Topology.

Unit II

- 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 damage and DNA repair (excision repair, mismatch repair and SOS repair), Genetic disease in humans. Recombination, Homologous Recombination, Holliday junction, FLP/FRT and Cre/Lox recombination, Rec. A 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, L-arabinose operon), DNA methylation, Heterochromatinization, Environmental regulation of gene expression.

Unit III

- 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 and types of RNA Polymerase in eukaryotes and prokaryotes, General and specific transcription factors, transcription signals, promoter sites, rho and sigma factor, Regulatory elements and mechanisms of transcription regulation, Transcriptional and post-transcriptional modification. 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.

Unit IV

- 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.

ZOO/I/CC/05	**Lab based on CC 01 to 04**	**Credits: 4**	**Max. Marks: 100**

SECOND SEMESTER: 20 CREDITS

ZOO/II/CC/01	**Cell Biology and Genetics**	**Credits: 4**	**Max. Marks: 100**

Unit I

- 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, Nucleus ER, Golgi complex and micro-bodies, 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, Na^+/K^+ pump.

Unit II

- Cellular communication: general principles of cell communication, cell adhesion molecules and roles of different adhesion molecules, gap junctions, plasmodesmata, extracellular matrix, selectins, Cadherins, 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 & Ca^{++} Calmodulin, signal transduction pathways, regulation of signaling pathways. GPCR Signaling, Wnt Signaling, Notch Signaling, Hedgehod Signaling, NO Signaling, RAS-MAP Signaling.

- 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.

Unit III

- 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. Concept of gene: Allele, multiple alleles, isoallele, pseudoallele.

- Chromosome mapping: Chromosome mapping in Drosophila (single and double crossing over), human chromosomes (Somatic cell genetics) Mutation: Type and mechanism and effects.

- Mendelian genetics: Dominance, segregation, independent assortment, Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and crossing over. Gene mapping, Point crosses, Qualitative trait loci (QTL), Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes.

Unit IV

- Microbial genetics: Methods of genetic transfers – conjugation ((F^+, F^- and High frequency recombinants strain HFR), 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.

ZOO/II/CC/02	Mammalian Endocrinology	Credits: 4	Max. Marks: 100

Unit I

- Brief history and scope of 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).

Unit II

- Hypothalamo-hypophysial System: General organization, Neuro-hypohysial 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.
- 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.

Unit III

- 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 hormones.

Unit IV

- 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).

- Environmental endocrinology: A brief knowledge of environmental endocrinology.

ZOO/II/CC/03	Biochemistry	Credits: 4	Max. Marks: 100

Unit I

- 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 chain (ETS) and Oxidative Phosphorylation. Inhibitors of ETS and oxidative phosphorylation.

Unit II

- Biomolecules; Chemical structure, classification and sources of biochemically significant carbohydrates. Chemical structure, classification and sources of biochemically significant lipids. Proteins – 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.

Unit III

- Metabolism of carbohydrates: Steps, enzymes and inhibitors 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. Glycosylation of proteins and glycosylation inhibitors. 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.

Unit IV

- Vitamins: Chemical structure, sources and deficiency state of fat soluble and water soluble vitamins.
- Minerals: Macro and micro nutrients. Sources and biochemical significance of minerals e.g. Sodium, Potassium, Calcium, Magnesium, Iron, Chloride, Zinc and Phosphorus and selenium.
- Basic concept of xenobiotic compounds and their metabolism. (Phase 1 and phase 2 reactions with examples).

ZOO/II/CC/04	Animal Physiology	Max. Marks: 100	Credits: 4

Unit I

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

- Human Digestive system - Digestion, absorption, energy balance, BMR. Sensory Physiology: Receptors, Pathways and physiology of smell and taste.

- Human Respiratory system - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Unit II

- Blood and circulation in Human - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, hemoglobin, immunity, hemostasis. Cardiovascular System: structure of myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

- Human Nervous system - Neurons, action potential, gross neuro-anatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture.

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

- Sense organs - Vision, hearing and tactile response.

Unit III

- Excretory system - Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.
- Muscle physiology: Structure, kinds and characteristics of muscles, Mechanism of muscle stimulation and contraction.

- Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. Temperature tolerance, Poikilothermic, Homoeothermic adaptations and regulatory mechanisms. Stress and adaptation.

- Biological Rules: Bergmann’s Rule, Allen’s Rule, Dollo’s Law, Gloger’s Rule, Jordan’s Rule and Cope’s Rule

Unit IV

- 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.

- Immune System: Immunity; Types of Immunity (Natural Immunity; Acquired Immunity: Active Immunity, Humoral Immunity, Cell mediated immunity); Structure of Antibody. Treatment of antibody with Pepsin, Papain, β-Mercaptoethanol and DMSO. 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, Autoimmunity); Allergy; AIDS

ZOO/II/CC/05	**Lab based on CC/ 01to CC04**	**Credits: 4**	**Max. Marks: 100**

THIRD SEMESTER: 20 CREDITS

ZOO/III/CC/01	Chordata	Credits: 4	Max. Marks: 100

Unit I

- Classification up to orders, characters, habits and habitats of chordates. Characteristic features and affinities of the following: Protochordata, Hemichordata, Urochordata, Cephalochordata, Cyclostomes, Dipnoi.

- Origin of the following: Amphibian, Reptiles, Birds, Mammals, Adaptive radiation in Chordates: Aquatic, Terrestrial, Aerial, Arboreal, Fossorial

Unit II

- Parental care in Amphibians, Skull in Reptiles, Venom and anti-venom in Ophidians

- Flightless birds, Modification of beaks (Darwin finches), feet and palate in birds, Dentition in mammals, Stomach in ruminants

Unit III

- General organization, classification and affinities of Cyclostomata, Gymnophiona and its affinities, Parental care in Amphibian, General organization, distribution and affinities of Rhynchocephalia.

- General organization, distribution and affinities of Crocodilian. Palate in Birds, Ratitae : Distribution and affinities

Unit IV

- Dentition in mammals, General characters, distribution and affinities of Prototheria and Metatheria, Aquatic and flying adaptations in Mammals

ZOO/III/CC/02	**Lab based on CC 01**	**Credits: 4**	**Max. Marks: 100**

ZOO/III/EC/01	Biotechnology	Credits: 4	Max. Marks: 100

Unit I

- Origin and definition of biotechnology, 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.

Unit II

- 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.

Unit III

- Genetic engineering in animals: transgenic animals and their applications. Transgenic gens and 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.

Unit IV

- 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, Wastewater treatment, chemical degradation, heavy Metals. Introduction to Bioreactor: types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors.

ZOO/III/EC/02	Animal Behavior	Credits: 4	Max. Marks: 100

Unit I

- 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)

Unit II

- 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)

- 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)

Unit III

- 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

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

Unit IV

- 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 Salmon, Eel and Hilsa.

- Biological Rhythms: Circa annual Clocks, Circa tidal Clocks, Circa lunar or Circa syndic Clocks, Semi lunar Clocks, Circadian Clocks

ZOO/III/EC/03	Bio-Instrumentation, Biostatistics and Computational Biology	Credits: 4	Max. Marks: 100

Unit I

- 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.

Unit II

- Chromatographic techniques, Paper chromatography, partition chromatography, column chromatography, thin layer chromatography, Gas Chromatography, ion exchange, affinity chromatography, Introduction to HPLC,
- Electrophoresis: Capillary, Agarose, SDS & Native PAGE, pulse field, immuno-electrophoresis, paper electrophoresis,.

- PCR & Thermal cyclers, Nucleic acid hybridization: Southern & Northern blotting, Western blotting, Autoradiography. ELISA, RIA.

Unit III

- 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.

Unit IV

- Introduction to Biostatistics, terminology and symbols, Research and types of research, applications of statistics in biological research, Data, collection and representation of data (Pie chart, Bar diagram, Histogram, Frequency polygon and Gantt chart), measures of central tendency (Mean, Median, Mode), Variance, Coefficient of variation, Standard Deviation, Standard error of mean, Analysis of variation (ANOVA), One way ANOVA and Two way 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 (SPSS and Excel data sheets).

ZOO/III/OEC/01	Developmental Biology	Credits: 4	Max. Marks: 100

Unit I

- Fertilization: Mechanism of fertilization, early and late changes in egg organization caused by fertilization, molecular events during fertilization. Mechanism of fertilization in Sea Urchin.
- Cleavage and Blastulation: Patterns of cleavage, determinate and indeterminate cleavage with examples, influence of yolk on cleavage, metabolic changes during cleavage, morulation and blastulation in frog, chick and rabbit, types of blastulae

Unit II

- Gastrulation: Fate maps, morphogenetic movements in frog, chick and rabbit, significance of Gastrulation, exogastrulation
- Development and functions of the foetal membranes in chick and mammals
- Organogenesis: Development of brain, eye and heart in chick
- Anterior and posterior regions development in *Drosophila melanogaster.* Role of polarity genes (hunchback, bicoid and nanos) in anterior and posterior regions.

Unit III

- Organizer Concept: Embryonic induction, primary organiser and its morphological differentiation, origin of primary organizer, inductive interactions, nature of inductive signal (Possible mechanism of neural induction) competence. Basic introduction to β-catenin pathway, ingression, epiboly, delamination, involution and invegination.

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

Unit IV

- 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

FOURTH SEMESTER: 20 CREDITS

ZOO/IV/CC/01I	General Ichthyology	Credits: 4	Max. Marks: 100

Unit I

- 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 (a) digestive system (with particular reference to food and feeding habits of freshwater fishes) (b) excretory system (with particular reference to acid base balance and osmoregulation.)

Unit II

- 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

Unit III

- Electric organs in fishes. Accessory respiratory organs in fishes.
- Brief knowledge of sexual dimorphism, courtship and parental care. Migratory instincts, Hill stream adaptations
- Reproduction in a major carps- structure of gonad, spawning, early development and metamorphosis. 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. Current trends in induced breeding in fishes.

Unit IV

- Brief knowledge of sense organs: organs of smell, eyes, hearing, ampulla of Lorenzeni, Bio-luminescence, sound production and lateral line system.
- Parental care in fishes. Venomous and non-venomous fishes. Fish pheromones. Coloration in fishes.

ZOO/IV/EC/01I	Applied Ichthyology	Credits: 4	Max. Marks: 100

Unit I

- Important cultivable fishes
- Important cultivable shellfishes
- Biology of cultivated fish and shellfish

Unit II

- Fish preservation, transport and marketing. Ecology and productivity of fish ponds. Pollution in relation to fisheries.
- Carp culture: Mono culture, Poly culture and Composite fish culture. Live fish culture. Management practices: weed, insect, and carnivorous fishes.

Unit III

- Maturation and fecundity, spawning and seed collection, Induced breeding, hatching techniques and hatcheries, nursery management, packing and transport of fish.

Unit IV

- 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.
- Larvivorus fishes and public health. Fish diseases and their management. Exotic fishes and their merits and demerits, Cryopreservation of gametes and embryos. Ornamental fish culture.

ZOO/IV/EC/I02	Basic Limnology	Credits: 4	Max. Marks: 100

Unit I

- Introduction and Development of Limnology in India
- Inland, waters Distribution of inland waters: Ponds, lakes, streams, rivers.

Unit II

- Lakes: Thermal Classification of lakes, Famous lakes of India and world, Nature of Inland water environment.
- Physical Characteristics: Pressure, Compressibility, Density, Mobility, Buoyancy, Movement of water, Thermal stratification, Light, Color, Turbidity.

Unit III

- Chemical characteristics: Dissolved gases – Oxygen, Carbon dioxide and other dissolved gases, Dissolved solids and Dissolved organic matter, Influence of physical and chemical conditions on living organisms in inland water bodies.
- Planktonic organisms: Classifications of organisms in water, Distribution of plankton, Food for plankton organisms

Unit IV

- Biological productivity, Circulation of food material, classification of lakes based on productivity, Laws of minimum, biotic potential and environmental resistance, quantitative relations in a standing crop
- Water pollution, eutrophication, algal blooms, water borne diseases, drinking water parameters
- Bioremediation of polluted water bodies.

ZOO/IV/EC/I03	Animal Ecology	Credits: 4	Max. Marks: 100

Unit-I

- Ecology: Its relevance to human welfare, subdivisions and scope. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

- Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

- Ecosystem's structure and function: Forest and Lake's biotic and abiotic components, primary and secondary productivity, movement of energy and materials, energy efficiency thermal stratification and circulation and lake's typology.

Unit-II

- Limiting factors: Laws of limiting factors, impact of temperature, moisture and pH on organisms. Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

- 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, interdemic extinctions, age structured. Altruism (Hamilton's Rule).

- Community ecology: Community attributes namely dominance, various types of diversity indices (Lincoln Peterson index, Simpson index, Shannon Weiner index, Brillouin index and Berger Parker index). Similarity coefficient and niche concept, community nomenclature.

Unit-III

- Stressed water 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.

- Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

- Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Unit-IV

- Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

- Biogeography: Major terrestrial biomes; theory of island biogeography; bio-geographical zones of India.

- Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Global conventions on environmental pollution (Kyoto protocol, Montreal protocol, Earth summit 2002 and Copenhagen accord).

- Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation /management strategy (Project Tiger, Biosphere reserves and lakes).

ZOO/IV/CC/01E	Systematics and Applied Entomology	Credits: 4	Max. Marks: 100

Unit I

- 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

Unit II

- 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, Phithioptera (Anoplura, Mallophaga), Isoptera, Thysanoptera, Heteroptera (Pentatomidae, Belostomatidae), Homoptera (Aphidae, Coccidae), Coleoptera (Coccinellidae, Curculionidae), Lepidoptera (Noctuidae, Nymphalidae), Hymenoptera (Ichneumonidae, Formicidae); Diptera (Muscidae, Syrphidae)

Unit III

- Principles and Practices of Pest Control:
- Pests defined: Categories of crop pests (key pests, occasional pests, potential pests and migratory pests)
- Pest control procedures: Natural control, Applied control (Cultural, Biological and Insecticidal)
- Modes of action of insecticides, factors affecting toxicity of insecticides
- Non-insecticidal methods : Antifeedents, Attractants and Repellents, Feeding deterrents, Chemosterilants, Pheromones and Insect Growth Regulators (IGR's)
- Integrated Pest Management (IPM)
- 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, Tribolium castaneum, Callosobruchus chinensis*); **Sugarcane** (*Pyrilla perpusilla, Chio infuscatellus*); **Paddy** *(Leptocorisa acuta*, *Hieroglyphus banian/nigrorepletus*), C**otton (***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 (Lo**custs, Termites)

Unit IV

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

Apiculture: Kinds of Honey bees and bee hives, structure of typical bee hive organization of Honey bees, the language of Honey bees, Bee keeping methods, economic importance and diseases of Honey bees. Parasites of honey bee (Varroa destructor, Varroa jacobsoni and Galleria mellonella).

Sericulture: Mulberry and Non-mulberry Sericulture, composition processing of silk and silk industry in India. Diseases of silkworm (White muscadine and Pebrine disease).

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

ZOO/IV/EC/E01	Biology of Insects (Morphology, Physiology & Development)	Credits: 4	Max. Marks: 100

Unit I

- 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

Unit II

- 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

Unit III

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

Unit IV

- Structure, function and physiology of mechanoreceptors and chemo receptors in insects
- Bioluminescence: Light producing organs, mechanism and significance of light production in insect
- 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

ZOO/IV/EC/E02	Economic Zoology and Vermicology	Credits: 4	Max. Marks: 100

Unit I

- The general study of parasites in terms of morphology, mode of transmission, symptoms, prevention and control.
- Types of parasites unicellular parasite. Protozoans (Endameba histolytica, Plasmodium spp.,) Trypanosoma spp. Leishmeniaspp. Etc.) Giardia and vector biology.

- Study: Multicellular parasites, Platyhelminths (tape worms, liver flukes) nemathelimuths (Ascaris) Loa-Nematoda/Onchocera volvulus.

Unit II

- Pests and Parasites, Apiculture, Sericulture, Lac culture, Pisciculture, Dairy, farming's products.
- Pesticides (organchlorines, arganophosphates, Carbanates, Pyrethroids, Triazmes, Bardeux nixture), Mode of action of pesticides, Advantages and disadvantages of pesticides Hazards of pesticides,
- Biological methods of pest control.

Unit III

- Earthworm Diversity: Classification earthworm types: white worm behavior of earthworms as indicators of soil Fertility, earthworms as bioreactors; earthworms and plant growth, organic matter-dynamics and nutrient cycling, feeding habit and food
- Vermicomposting :Advantages of Vermicomposting, Vermicomposting in daily life, Vermiculture vs Vermicomposting, Chemical compostion of vermicompost vermicomposting at home and agricultural farm; the business of worms; interaction of vermicompost earthworms.

Unit IV

- Earthworm Bio-technology:Fundamentals of sustainability; Enrichment of Vermicompost and earthworms for sustainable production, earthworms in bio-remediation, earthworms in alternative medicine, earthworm meal production transgenic earthworms.
- Organic Farming: Eco-friendly farming system technology's, Criteria for ecological. Evaluation study of ecological constraints (climatic, edaphic,). appropriate technologies, in agro-forestry, natural-management, Planted forests, (ranching, farmers perception to organic farming, any case study).

ZOO/IV/EC/E03	Wildlife Conservation	Credits: 4	Max. Marks: 100

Unit I

- Indian Wildlife: Introduction, distribution of wildlife in ecological subdivision of India, IUCN categories
- Protected area network: national parks, wildlife sanctuaries, biosphere reserves and zoos in India, gene pool, habit, habitat and breeding biology of few mammals (viz., elephant, tiger).

Unit II

- Reasons for wildlife depletion: Habitat fragmentation, habitat destruction, commercial wildlife exploitation, overgrazing etc.,
- Wildlife conservation (policies and programmes), special projects for endangered species (Project Tiger, Gir Lion Sanctuary Project, Crocodile Breeding Project).

Unit III

- Principle and practice of wildlife management: Management of special habitats; riparian zones, grasslands Introduction to conservation biology, conservation values and ethics of conservation of natural resources.
- Conservation of biodiversity, patterns and processes, concepts of biodiversity, levels of biodiversity, genetic diversity, intra specific diversity, species richness, richness of higher taxa, ecosystem and biome diversity.

Unit IV

- International conventions on conservation (Ex-situ and in-situ conservation, conservation breeding (e.g. Vulture, Pygmy hog, Gharial, etc.), institutions and their role in conservation (Zoos, Natural History Museums and Collections, Zoological Survey of India and its regional centres.
- National and international zoological institutes, societies and academic bodies.
- Brief account of Wildlife Acts and their amendments in India and World. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

ZOO /IV/CC/01B	Animal Biotechnology (Animal cell Culture)	Credits: 4	Max. Marks: 100

Unit I

- 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.

Unit II

- 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- carries and perfusion techniques.
- Measurement of viability and cytotoxicity. Biological characterization of the cultured cells, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures.

Unit III

- Fermentation technology for the growth of animal cells and their products (Bioreactors, Hollow fiber reactors,Air-lift fermentors, chemostats and microarriers). 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.
- 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.

Unit IV

- 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 substituents, artificial blood. Harvesting of products, purification, and assays. Three dimensional cultures and tissue engineering (artificial skin and artificial cartilage).

ZOO /IV/EC/B01	Animal Biotechnology (Transgenics, cloning and IPR)	Credits: 4	Max. Marks: 100

Unit I

- 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.

Unit II

- 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).

Unit III

- 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.

Unit IV

- 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).

ZOO/IV/EC/B02	Medical Laboratory Techniques	Credits: 4	Max. Marks: 100

Unit I

- Basic laboratory principles - Code of conduct of medical laboratory personnel. Organization and functioning of clinical laboratory. Safety measures - safety equipment's, safety symbols.
- Hazards in the laboratory (chemical hazards, clinical hazards, electrical hazards, biological hazards. Waste disposal.

Unit II

- Introduction of Common Laboratory Equipment's: Hot Air Oven, Incubator, Autoclave, Water Bath, Centrifuges
- Microscope - Fundamentals of Microscopy, Resolution and Magnification, Light Microscopy, Electron Microscopy, PCR, Electrophoresis, UV trans illuminator etc.

Unit III

- Specimen Collection, Processing and Analytical Techniques Collection and preservation of blood, urine, stool, sputum, pus, body fluids, swab.
- Preparation of blood smears. Sources of biological variations, pre-analytical variables.

Unit IV

- Preparation of reagents: Buffers and pH, Normal, percent and molar solution, normal saline -Methods of measuring liquids.
- Clinical Laboratory records - Modern Laboratory set up - Quality control: Accuracy, Precision, and Reference values.
- Disposal of biomedical waste
- laboratory safety protocols and guidelines

ZOO/IV/EC/B03	Wildlife Conservation	Credits: 4	Max. Marks: 100

Unit I

- Indian Wildlife: Introduction, distribution of wildlife in ecological subdivision of India, IUCN categories
- Protected area network: national parks, wildlife sanctuaries, biosphere reserves and zoos in India, gene pool, habit, habitat and breeding biology of few mammals (viz., elephant, tiger).

Unit II

- Reasons for wildlife depletion: Habitat fragmentation, habitat destruction, commercial wildlife exploitation, overgrazing etc.,
- Wildlife conservation (policies and programmes), special projects for endangered species (Project Tiger, Gir Lion Sanctuary Project, Crocodile Breeding Project).

Unit III

- Principle and practice of wildlife management: Management of special habitats; riparian zones, grasslands Introduction to conservation biology, conservation values and ethics of conservation of natural resources.
- Conservation of biodiversity, patterns and processes, concepts of biodiversity, levels of biodiversity, genetic diversity, intra specific diversity, species richness, richness of higher taxa, ecosystem and biome diversity.

Unit IV

- International conventions on conservation (Ex-situ and in-situ conservation, conservation breeding (e.g. Vulture, Pygmy hog, Gharial, etc.), institutions and their role in conservation (Zoos, Natural History Museums and Collections, Zoological Survey of India and its regional centres.
- National and international zoological institutes, societies and academic bodies
- Brief account of Wildlife Acts and their amendments in India and World. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

ZOO /IV/CC/01IM	Fundamentals of Immunology	Credits: 4	Max. Marks: 100

Unit - I

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 Eldelman 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]

Unit - II

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

Antigen- definition and its properties. Immunogen-definition and its properties. Antigenecity vs. Immunogenicity and factors affecting it. Haptens and Adjuvants. Basic structure of immunoglobulin. Classes of immuglobulin 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.

Unit - III

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.

Structure of antibody, Treatment of antibody with pepsin, papain, β-mercaptoethanol and DMSO. Interaction of Antigen-Antibody- antibody affinity, antibody avidity, cross reactivity, precipitation reactions, Agglutination reactions.

Unit - IV

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_{DTH}-Mediated [type IV] hypersensitivity.

ZOO /IV/EC/1IM01	Applied Immunology	Credits: 4	Max. Marks: 100

Unit - I

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*].

Unit - II

Disease of immune system and vaccines:

Mechanism of autoimmune diseases- Systematic Lupus Erythromatous [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.

Unit - III

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.

Unit - IV

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.

ZOO/IV/EC/IM02	Animal Ecology	Credits: 4	Max. Marks: 100

Unit-I

- Ecology: Its relevance to human welfare, subdivisions and scope. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.
- Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
- Ecosystem's structure and function: Forest and Lake's biotic and abiotic components, primary and secondary productivity, movement of energy and materials, energy efficiency thermal stratification and circulation and lake's typology.

Unit-II

- Limiting factors: Laws of limiting factors, impact of temperature, moisture and pH on organisms. Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).
- 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, interdemic extinctions, age structured. Altruism (Hamilton's Rule).
- Community ecology: Community attributes namely dominance, various types of diversity indices (Lincoln Peterson index, Simpson index, Shannon Weiner index, Berger Parker index and Brillouin index). Similarity coefficient and niche concept, community nomenclature. Lotka-Voltera Model of species competition.

Unit-III

- Stressed water 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.
- Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
- Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Unit-IV

- Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.
- Biogeography: Major terrestrial biomes; theory of island biogeography; bio-geographical zones of India.
- Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Global conventions on environmental pollution (Kyoto protocol, Montreal protocol, Earth summit 2002 and Copenhagen accord).
- Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation /management strategy (Project Tiger, Biosphere reserves and lakes).

ZOO/IV/EC/IM03	Medical Laboratory Techniques	Credits: 4	Max. Marks: 100

Unit I

- Basic laboratory principles - Code of conduct of medical laboratory personnel. Organization and functioning of clinical laboratory. Safety measures - safety equipment's, safety symbols.
- Hazards in the laboratory (chemical hazards, clinical hazards, electrical hazards, biological hazards. Waste disposal.

Unit II

- Introduction of Common Laboratory Equipment's: Hot Air Oven, Incubator, Autoclave, Water Bath, Centrifuges
- Microscope - Fundamentals of Microscopy, Resolution and Magnification, Light Microscopy, Electron Microscopy, PCR, Electrophoresis, UV trans illuminator etc.

Unit III

- Specimen Collection, Processing and Analytical Techniques Collection and preservation of blood, urine, stool, sputum, pus, body fluids, swab.
- Preparation of blood smears. Sources of biological variations, pre-analytical variables.

Unit IV

- Preparation of reagents: Buffers and pH, Normal, percent and molar solution, normal saline -Methods of measuring liquids.
- Clinical Laboratory records - Modern Laboratory set up - Quality control: Accuracy, Precision, and Reference values.
- Disposal of biomedical waste
- laboratory safety protocols and guidelines

ZOO/IV/OEC/ 01	**Minor Project (In-house) on Final Semester special papers (I,II and III)**	**Credits: 4**	**Max. Marks: 100**

ZOO/IV/CC/02	**Lab based on specialization paper 1 and 2**	**Credits: 4**	**Max. Marks: 100**

ZOO/I/CC/05	Lab based on CC 01 to 04	Credits: 4	Max. Marks: 100

Practical (As per availability and feasibility) in all semesters

Ist Semester Practical (As per availability and feasibility)

- 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& Biuret 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

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

Experiments on Ecology:

1. Calculation of similarity index between different communities.
2. Calculation of concentration of dominance for different communities.
3. Calculation of Shannon Weiner Index of diversity in different communities.

4. Determination of salinity and chlorinity in water samples.
5. Determination of moisture content and total organic matter in soil sample.
6. Determination of dissolved oxygen.
7. Determination of free CO_2 in water sample.

Microbiology:

1. Preparation of culture media for bacteria
2. Staining of microorganisms
3. Antibiotic sensitivity test.
4. Bacteriological testing of milk.
5. Isolation and characterization of intestinal pathogens.

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

Evolutionary Biology and Systematics:

1. Study of evolution of horse, elephant, and man (through charts/ models.)
2. Adaptive modification in feet of birds/mouthparts of Insects (through charts/ slides).
3. Embryological evidences of evolution (through chart).
4. Analogy and Homology (wings of birds and insects, forelimbs of bats and rabbits through charts.)
5. Identification of local fauna on the basis of their morphological characters (5 each)
6. Construction of a dichotomous key.
7. Zoological names of some local fauna.
8. Taxonomy of Drosophila. (Chaetotaxy)

ZOO/II/CC/05	Lab based on CC/ 01to CC04	Credits: 4	Max. Marks: 100

Semester -2

- 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 Tm of nucleic acid.
- Bacterial transformation.
- Isolation of Plasmids.
- Agglutination
- ELISA (Demo online)
- Immunofluorescence 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.
- Immunodiagnostics (demonstration using commercial kits)
- Identification of blood group.
- Estimation of hemoglobin 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, Km of the enzyme.
- Bioinformatics –tools on line

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:

- Experiments on Physiology and Bio-chemistry: Chemical test of urine for the presence of urea, sugar, proteins and ketone bodies
- Tests for carbohydrates, proteins and lipids
- Action of Amylase on its respective substrates
- Determination of Haemoglobin (gm %) in human blood; also calculation of colour index and the mean corpuscular haemoglobin concentration
- Estimation of total leucocyte number per cubic mm of frog and human blood
- Differential count of leucocytes in the human blood
- Estimation of total erythrocyte count per cubic mm of blood
- Cell permeability of RBC of human blood in saline solution of different concentrations
- Cytology:
- Study of different stages of mitosis with the help of onion root tip
- Study of different stages of meiosis with the help of grasshopper testis
- Laboratory preparation of following models using beads and wire
- Adenosine triphosphate (ATP)
- DNA and RNA bases
- Nucleosides
- Nucleotides
- Morphological study of Drosophila
- Preparation of chromosomal maps in Drosophila based on percent of crossing over
- Genetics exercise (data to be provided)
- Endocrine glands of rat, insect (Location through models, Charts)
- Endocrine disorders (Photographs)

ZOO/III/CC/02	Lab based on CC 01	Credits: 4	Max. Marks: 100

III[rd] Semester Practical

- 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.

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**

- Study of the skeleton of Frog, Varanus, Chelonia, Crocodile, Snake (vertebrae and skull of poisonous and non-poisonous snake), Gallus (various types of Palates) and Rabbit
- Study of permanent slides of Protochordates and Chordates
- Study of the museum specimens of Protochordata and of the different classes of vertebrates

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

1. Instrumentation:

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

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

ZOO/IV/CC/02	Lab based on specialization paper 1 and 2	Credits: 4	Max. Marks: 100

- Preparation of tissue culture medium and membrane filtration
- Preparation of single cell suspension from spleen and thymus
- Preparation serum
- Egg 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.

List of Few Recommended Books

1. Kuby's immunology- Goldsmith et al, 6th 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, 8th Ed, Garland Science, Pennsylvania, USA.
4. Roitt's Immunology- Delves et al, 12th Ed, Willey-Blackwell Science, Oxford, UK.
5. History of Immunology, 2nd Ed- Silverstein [2009], Academic Press, New York, USA.
6. Exploring immunology: Concepts and Evidence- Macpherson and Austyn, Willey-Blackwell Science.
7. Kuby's immunology- Goldsmith et al, 6th Ed, WH Freeman, New York, USA.
8. Practical Immunology, 4th Ed. Hay and Westwood [2002]. Blackwell Science Ltd, Oxford, UK.
9. Advanced method in cellular immunology. Fernandez-Borton and Velvaticka [2000]. CRC press, Washington, USA.
10. Clinical immunology and Serology: a practical perspective, 3rd Ed. Stevans [2010], FA Davis co. Philadelphia, USA.
11. Biotechnology (2007), U. Satyanarayana ,Book and Allied (p) LTD.
12. Plant Biotechnology Second edition (2004) ,H.S.Chawla, Oxford & IBH Publishing Co.Pvt.Ltd.
13. Vertebrates (2014), R.L.Kotpal, Rastogi Publication .
14. Animal Physiology and Related Biochemistry , H.R Singh, Vishal Publication Jalandhar City.
15. Vermicomposting for Sustainable Agriculture (2005), P.K.Gupta ,Bharat Printing Press ,Jodhpur.
16. Immunology (2005),Nandini shetty, New Age International (p) Limited, Publishers.
17. Analytical Chemistry ,G L David Krupadanam, Universities Press (India) Limited.
18. Cell Biology, Genetics , Molecular Biology, Evolution and Ecology (2012), P.S.Verma , S.Chand & Company Ltd.
19. Genetic Engineering (2001), Sandhya Mitra , Rajiv Beri for Macmillan Indian Limited.
20. Bioinformatics (2003), D.R. Westhead ,Bios Scientific Publishers Limited.
21. General Microbiology Seventh edition(2006), Hans G.Schlegel. Cambridge University press.
22. Extranuclear Genetics ,Geoffrey beale, Edward Arnold Publishers Limited.
23. Basic Molecular biology (2005), Avinash & Kakoli Upadhyay ,Himalaya Publishing house.
24. Fish Genetics & Biotechnology (2000), W.S.Lakra, Central Institute of Fisheries Education .
25. Genetic Analysis Seventh edition ,Anthony J.F.Griffiths, W.H.Freeman.
26. The Fresh Water Fishes of The Indian Region (2002),K.C Jayaram, Narendra Publishing House.
27. Analytics Techniques in Agriculture, Biotechnology and Environmental Engineering(2006),A.Nag, Prentice Hall of India Private Limited.

28. Fish Biology and Fisheries (2006), S.S.Khanna, Narendra publishing house.
29. Calculations for Molecular biology and biotechnology (2004),Frank H.Shephenson ,Academic press.
30. Pharmaceutical Microbiology (2008) ,Ashutosh kar , New Age International publishers.
31. Animal Cytology and Evolution Third edition, M J D White , Vikas Publishing house.
32. Genetics fifth Revised edition (2004), Mohan P. Arora , Himalay Publishing house.
33. Elementary Biochemistry , J.L.Jain , S.Chand & Company LTD.
34. Biotechnological Methods of Pollution Control, S.A Abbasi , Universities press.
35. Essentials of Animal Physiology Fourth Edition (2011), S .C. Rastogi , New Age International LTD
36. The Genetics of Bacterial and Their Viruses ,William Hayes, CBS Publishers & Distributors.

Recommended Journals:

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

Recommended research database:

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

List of Recommended Practical Books